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REINFORCED CONCRETE SUBURBAN RESIDENCE CONSTRUCTION.

By Wm. F. Tubesing.*

The accompanying views show two residences constructed of reinforced concrete in the vicinity of Cincinnati, O., after designs by Mr. Gordon Shepard, architect of that city. The design and construction of the J. R. Ware residence will be considered in detail; the view of the R. Anderson residence is shown merely to indicate the variety of design and effect possible. Both residences were built by the Ferro Concrete Construction Co., of Cincinnati, O., whose engineers designed the reinforced concrete structure.

The J. R. Ware residence is located on the beautiful highlands along the Ohio River near Fort Thomas, Ky. Everything in the construction except the hardwood floors, inside woodwork, and the understructure of the roof is of reinforced concrete construction. This includes all outer walls, floors, columns, cross-beams and chimneys. The partitions are built of light terra cotta.

The building is 40 ft. × 37 ft., and has a veranda 10 ft. wide and 76 ft. long. The floors and posts of the veranda are of reinforced concrete, while the railing and understructure of the roof are of wood. The roof is of red tile. The house consists of a basement, first floor, second floor and an attic. The basement is divided into a large laundry and furnace room, and has a flight of wooden stairs leading up to the kitchen. On the first floor is a large reception hall 8 ft. × 29 ft. Large folding doors open into the parlor and library. The dining-room adjoins the library, and is connected to the kitchen by a serving-room 6½ ft. × 8 ft. There are practically 255 sq. ft. of floor space in the dining-room, 218 sq. ft. in the parlor and library, and 158 sq. ft. in the kitchen. At the end of the reception hall a broad stairway leads to a middle landing. Stained glass windows reach from the window seat on this landing to the ceiling. Four bedrooms of practically 218 sq. ft. each open into the upper hall. At the end of the hall the bath and toilet rooms are located. The floors of these are done in mosaic and the walls are of white tile. The attic is finished and is divided into servants' rooms.

As the house is built on the side of a ravine, it was necessary to step the footing. The footing is 6 ins. deep and 2 ft. wide. Upon it rests a 7-in. cellar wall, which is grooved every foot on all exposed sides of the exterior face of the wall. The footing is 4 ft. below the present grade, which will be raised about 6 ft. higher and leveled off. The columns are carried by three stepped piers, which are 4 ft. × 4 ft. at the base.

The floor system of the first floor is carried by three 12-in. × 12-in. columns (Fig. 3), with four ½-in. square steel Ransome rods hooped with ¼-in. square steel rods every 12 ins. Two extra columns were added to the original design at the places marked X. The beams of the first floor were computed for a load of 60 lbs. dead and 65 lbs. live load, while the second floor loading was 50 lbs. live and 60 lbs. dead. They are of the following dimensions:

REINFORCED CONCRETE RESIDENCE OF J. R. WARE NEAR CINCINNATI, OHIO.

No.	Span, ft.	Span, ins.	Width, ins.	Depth, ins.	Reinforcement
A	15	0	6	18½	1-1-in. sq. bar
B	17	0	6	18½	2-1-in. sq. bar
C	5	6	6	9½	1-1½-in. sq. bar
D	8	0	3	7	1-1½-in. sq. bar
E	10	0	3	10¼	1-1⅝-in. & 1½-in. sq. bar
F	10	0	3	7½	1-1⅝-in. & 1½-in. sq. bar

By depth of beam is meant the distance from the top of floor to the bottom of beam. Ransome bars were used.

The reinforcement of the floor slabs varies as the span. For the large spans ⅝-in. square bars, 6 ins. c. to c., crossed by ⅜-in. bars, 5 ins. c. to c., are used. For the spans over the hallways ⅝-in. square rods, spaced 7½ ins. c. to c., while on the rear porch ¼-in. rods were placed. The floors of the house, all but the small spans, are 4 ins., the small spans being 3 ins. deep. On the first floor a cantilever platform was built on account of the hole cut into the floor for the steps from the cellar. The reinforcement in this platform consisted of ⅝-in. square bars, 6 ins. c. to c., placed in top of the slab.

The upper walls are 6 ins. thick, and fireplaces are built into the walls by having the wall project 15 ins. towards the inside of the room. The openings of the fireplaces are 2 ft. 2 ins., with 1 ft. 5 ins. on the sides.

All of the concrete was mixed in the following proportions: 1 of cement, 2½ river sand and 5 parts of screened river gravel.

After the footings and piers were built the house, so far as the concrete work was concerned, was built in three sections. The forms for the basement walls and columns and floors being built, the concrete was placed in one operation. The steel rods were allowed to project in order to secure a proper bond for the next section. After the first section had properly set the form work was removed and the same material used to build the forms for the walls, columns and floors of the first story. The concrete was then placed, and after it had set work was begun on the third section, which consisted of the walls and columns of the second floor and the attic floor. This method of construction greatly decreases the cost of lumber used. The form work for a building of this kind is built up like the sidings of a frame house reversed.

Probably the most interesting part of the construction of this house is the white marble finish of the exterior walls. The walls are not marked by variously colored stains, such as are seen on most concrete jobs. The finish consists of sand and Ladd's hydraulic lime, which is manufactured in Georgia. The two materials are mixed half and half, forming a thick paste, which is applied to the rough concrete walls as a dashed coat stucco. About the only disadvantage of the lime is the time it takes to slake it. A house built at Oakley, O., in 1893 was built of a lime concrete composed of coarse bank sand, gravel and crushed furnace slag and Ladd's lime slaked in a pit dug in the ground. The mixture formed a concrete as hard as any Portland cement mixture and was as white as marble. It does not discolor, and its durability is well shown in the house at Oakley.

The roof consists of red American S tile, and is supported by an understructure of pine. The white surface of the walls, in conjunction with the red tile roof, affords as effective a picture in

*Office of Chief Engineer, Commissioner of Water-Works, Cincinnati, Ohio.

contrast with the surrounding landscape as one could wish to see.

The interior woodwork, except the stairway leading to the second floor and the mantles, are of soft woods. The first floor is furnished entirely in white, which, with the mantles, gives a very homelike and clean appearance. The second floor and stairway are done in brown. The mantles have speckled pale green tile.

FIG. 1. REINFORCED CONCRETE RESIDENCE OF R. ANDERSON NEAR CINCINNATI, OHIO.

The sand and gravel were supplied by Mr. J. R. Ware himself, and he estimated the cost of the building at $10,000 to $12,000. The building was begun in July, 1904, and was completed in September for concrete work and in December for occupation.

A COMPARISON OF ENGLISH AND AMERICAN METHODS OF BUILDING CONSTRUCTION.

At a recent meeting of the Royal Institute of British Architects a brisk discussion took place on the relative merits of English and American building methods. The discussion was started by a paper read before the institute by Mr. R. A. Denell, Managing Director of the Waring-White Building Co., one of the allied British interests of J. G. White & Co., of New York. Mr. Denell's paper was entiled "American Methods of Erecting Buildings."

A strong point was made of the benefits of the American system of the co-ordination of the purely architectural training with training in the general business of contracting. It seems that far less harmony exists between the architect and the builder in Great Britain than is the case with us. The fact that the best American builders have, as a general rule, served architectural apprenticeships occasioned more remark.

Continuing, Mr. Denell took up the special topic of the surprising speed with which large buildings are run up in America, and ascribed much of the superiority in this respect to the fact that building materials in this country are usually supplied by large concerns devoted solely to the output of a single class, and therefore in a position to execute rapidly the largest orders. It will doubtless be a revelation to many American builders that the old-time plan of the direct preparation of all materials by one contracting company still endures on the other side of the water.

In addition, Mr. Denell ascribed the speed superiority of American practice to the prevalence of the steel structure, to the greater care in supervision of labor, and to the more rigid restriction by British laws in the amount of material that can be stored on the work.

The organization of the typical large architectural firm in the "States" was detailed at length in the paper, with emphasis laid upon the assumption by such firms of purely engineering functions. This stage has not yet been reached in English building progress. Again, the British builders' working drawing contains no dimensions, and to work with one implies the continual use of a scale.

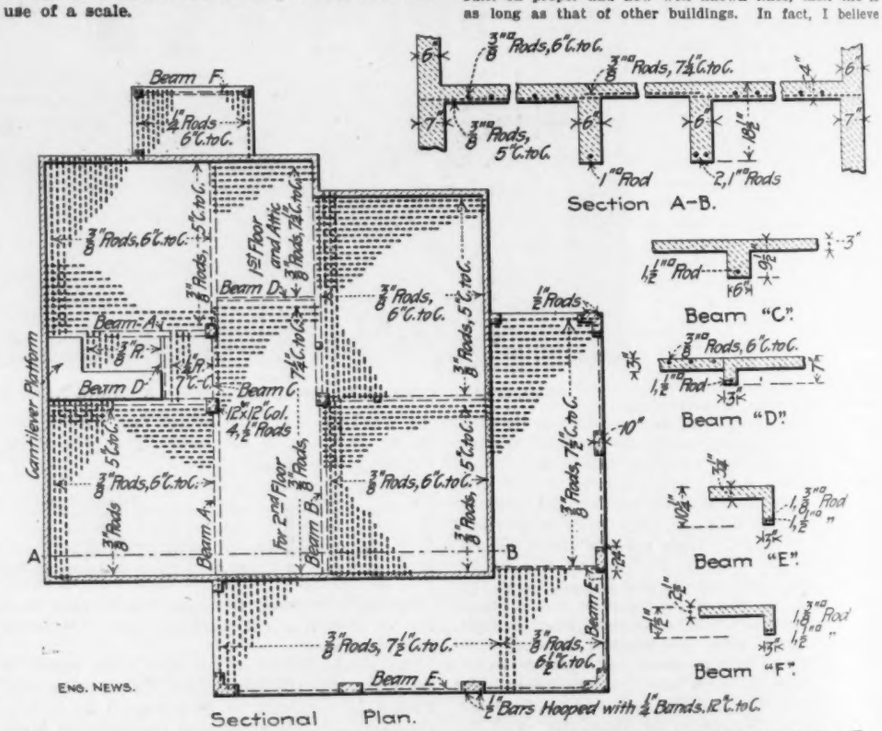


FIG. 2. PLAN OF J. R. WARE RESIDENCE, SHOWING ARRANGEMENT OF REINFORCEMENT.

Regarding building materials, the American architect has a greater latitude in the choice of a color scheme, because of the greater variety of natural colors in American brick. In stones, America boasts a greater variety, both of quality and of color, but white limestone is the favorite in both countries. The British islands lead in the production of the dark granites, according to Mr. Denell; but he believes the buildings here more fortunate in his supply of gray granites, and that American marble is excelled in quality only by the Grecian.

The widespread use of terra cotta in America also received commendatory notice, with an admission that in its manufacture and application the palm comes to this side. Reason for superior development along this line here was believed to lie particularly in the fact that the material is so thoroughly adapted to the decoration of the steel structures, and in a lesser degree to the wider range of natural colors obtainable.

America was not so fortunate in that portion of the paper devoted to staircase building methods, as the author condemned "over-indulgence" in iron construction. The English concrete construction should be chosen whenever possible, for its superior fire-resisting properties, if for no other reason.

An accurate general comparison of the cost of building on the two sides of the water was drawn by Mr. Denell on a careful study of specific cases, and the fact deduced that building in Great Britain costs about the same as building in the Middle West, a common figure 10% cheaper than building in New York. Explanation was found in the difference between the cost of labor and the cost of material here and abroad.

Quite as interesting as any feature of Mr Denell's dissertation is the statement of his professional opinion on the "skyscraper," regarded from the structural as well as from the economic standpoint. We quote as follows:

> Now and again tales are heard of 40-story buildings. I believe, while these could be structurally and safely built, especially if the base were large enough, that the practical commercial building will not be higher than 20 stories, and that will soon be the limit. The cost of maintenance above the first twenty stories, and the great loss of space on the first twenty stories occupied by elevator, etc., to reach the upper stories, as well as the increased cost of construction, will not be counterbalanced by the amount of rentable space gained.
>
> As regards the life of these steel frame buildings, when built on proper and now well known lines, their life is as long as that of other buildings. In fact, I believe that modern conditions of life are changing faster than buildings depreciate, thus necessitating rebuilding before their life is run. The steel is all buried in concrete, all exterior columns being encased in brickwork, and the interstices grouted full of cement mortar. The interior columns are treated in the same way, bricks or

fire clay being used for covering. In addition the columns themselves are now being filled internally, while being erected, with concrete, and it is a well known fact that the encasing of steel in cement concrete, thus excluding air, prevents corrosion.

A great many persons feel that rapidity in construction means poor work; this view I oppose. It is possible that such a limit could be reached, and is perhaps sometimes; but the general statement that fast work means poor work is untrue. For instance, it could not be considered "rushing work" to have a sufficiency of materials, etc., ready to enable a number of men to be engaged all over a large building, doing their work properly, rather than a few men in one section only and allowing the other sections to stand idle until they were through.

I am aware that there is a good deal of doubt among architects here as to the aesthetic legitimacy of steelwork, as there was in the United States at one time, although the opposition is much weaker now. It seems to me that steelwork is not outside of the pale of the art of architecture. I have endeavored to show that there are logical reasons for the adoption of steel frames in buildings; and if there is reason, then surely steel cannot be inartistic any more than timber. There is a question, of course, of the legitimate clothing of the skeleton as to how far this should be expressed; but there is nothing against the frame itself, no more than the skeletons in our bodies.

The President of the Institute of Builders, Mr. Benjamin Greenwood, opened the discussion with a series of remarks tinged by a gentle satire. He believed his confreres would be filled with admiration for American methods. Mr. Greenwood did not believe that the "skyscraper" would ever be adopted in London, and he hoped that that monstrous example of such a building near St. James' Park would prove a blessing in disguise by discouraging further attempts along those lines.

Mr. John Slater acknowledged that there was a peculiar interest attached to the "skyscraper," and, referring to the work of the Waring-White Co., was impressed by the rapidity with which certain frame buildings in London had been run up. However, he personally objected to a system which deprived the architect of the prerogative of altering plans during construction, as this system certainly must do.

Finally, this speaker hoped, with Mr. Greenwood, that he would never see in London any such constructions as Mr. Denell had shown them, for he could never inhabit any room in such a building without the feeling that it might be blown down.

Mr. Howard Colls, called upon by the President for his opinions, exhibited in their delivery a curiously apprehensive conservatism. We quote as follows:

> One of the most charming, or what they call in America most charming buildings in New York is the Flatiron Building. But the draft there is so strong that no lady could walk by the side of that building—she would be frightened to do so; her clothes would become disorganized and be blown to pieces. Some of the buildings I have seen in New York struck me as imposing-looking, but these were isolated. If buildings like these had been erected all along the street, and the general buildings of New York were of that height, there would never be any sun in the streets at all; and I doubt if anybody would be able to walk about there. It would be obvious to everybody that if we put buildings in our streets that prevent the streets being used the result could not be considered satisfactory.

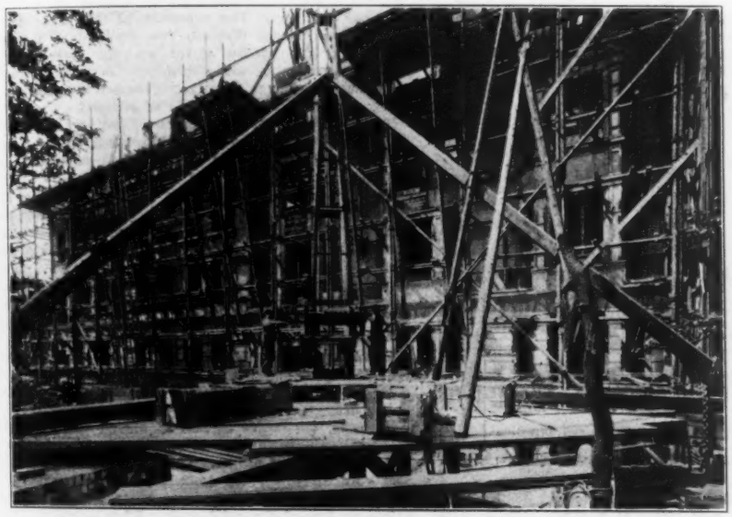
In conclusion, Mr. Colls drew the distinction between "speed" and "hurry," and declared that speed in American building was a misnomer; that it was in reality absolutely nothing but hurry, engendered by a mere love of hurry, and, altogether, a grave menace in modern building. In his opinion, speed and stability in building were necessarily incompatible.

After the foregoing demonstration of hostility, the moderate comment of Mr. William Woodward came as a decided relief. He believed that delay in the completion of buildings was more often to be ascribed to negligence in looking ahead than to any other one factor, and that in this particular American practice outstripped English. Furthermore, he did not believe with the previous speaker that deliberation in erection was an essential to sound building, or that American speed was synonymous with hurry, and therefore to be frowned upon.

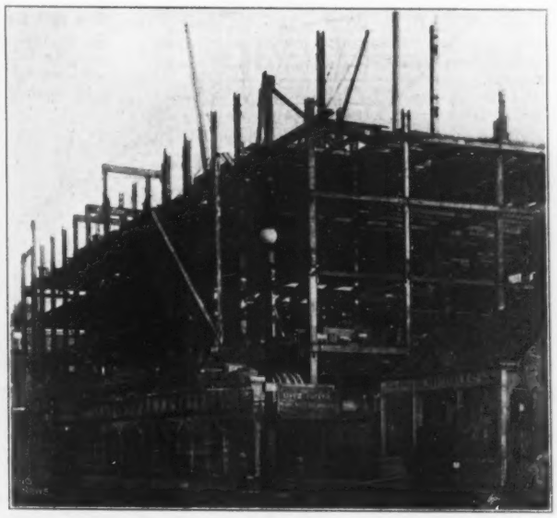
Finally, it seemed to Mr. Woodward that the conditions which had bred the "skyscraper" in New York were equally potent in London, and that it must be perfectly evident that they must soon begin to move with the times.

The President of the Institute, Mr. John Belcher, A. R. A., very pithily summed up the whole situation in the conclusion of his remarks while putting the vote of thanks to Mr. Denell, as follows:

> We have learned two lessons from the paper: one, that we must not lag behind; and the other, that we must take every advantage of all improved methods that we can, consistently with the production of good work. In the steel-frame work we have a very serious problem, and I cannot help feeling that if anything of that sort were developed to any great extent, we should all have to become engineers instead of architects. Architects seem to me in such cases to take a very secondary place, and it is necessary for us to look the thing in the face and ascertain whether we are in a position to become engineers as well as architects.



A Typical Example of English Scaffolding on Building Construction.



The New Ritz Hotel; Waring-White Building Co., Contractors.

A COMPARISON OF ENGLISH AND AMERICAN METHODS OF BUILDING CONSTRUCTION IN LONDON.

THE GENERAL FUTILITY OF FORFEITURE CLAUSES IN MUNICIPAL FRANCHISES.

In granting franchises to public service corporations, municipalities are altogether too willing to rely upon some vague general clause for the protection of their interests, or upon a blanket forfeiture clause, providing that in case of non-fulfilment of the terms of the franchise the latter shall become null and void. Some reflections on franchise forfeitures were submitted to the Michigan Engineering Society in January, 1906, by Mr. W. W. Brigden, of Battle Creek, Mich., a part of which we quote, as follows:

> To those on the municipal side of the question, it seems a company could be compelled to meet the requirements of its franchise to any extent, but we should remember the company must have protection and, while the promoters and early owners may have plundered until there is no great value left in the property, still there are the owners of the bonds, creditors and innocent purchasers to be looked after, and this the courts seem determined to do to an extent that sometimes seems scarcely justifiable, when it is known the franchise is really a contract. So far as the writer is able to determine, courts often refuse to carry out a penalty which involves forfeiture of franchise, even although it may be clearly set forth in the contract. In fact, it seems the courts are placing the innocent investor, or the investor who is supposed to be innocent, in a surer way to have his interests cared for than are those of the municipality. Probably this is the outcome of gross injustice done to investors under similar circumstances, but it is certainly a warning to municipalities not to insert in franchises the penalty of forfeiture for failure to keep the more ordinary provisions of the contract, as, if done, it leaves the failure in question without penalty. It will be better, therefore, except in a few of the more important points, such as failure to operate the road for any considerable time, to insert some other penalty.

Another point made by Mr. Brigden was that rapidly changing technical conditions render useless after a few years what were originally well-conceived franchise provisions. As a remedy for this and other franchise complications he very properly suggests as short-term franchises as capital will accept, "say 20 years in ordinary cases," and

> as full and clear a contract as possible under existing conditions, and provide by arbitration, or some other means, for settling difficulties and disputes, both as to the franchise and the unlooked for changes in operation and construction that are quite sure to take place in the future.

FORESTRY ON THE DRAINAGE AREA of the waterworks of Oberlin, O., has been inaugurated. The work accomplished and proposed is outlined in the Annual Report for 1905 of Mr. W. B. Gerrish, Engineer and Superintendent. When the works were originally built the funds available permitted the acquirement of only ¾ of an acre of land at the dam and intake. The land immediately above the intake was used for pasturage. In 1903, 195 acres of this land was bought for $6,600. Arrangements were made with the Ohio Agricultural Experiment Station, at Worcester, O., through Prof. W. J. Green, Horticulturist, under which the station agreed to supply trees and expert advice, and the village agreed to furnish the necessary labor, the latter not to exceed an outlay of $300 per year for five years. In the spring of 1905 there were set out 8,700 catalpas, 3,000 locusts, 2,000 white ash, 500 mulberry and 500 walnut trees. The season was very favorable and nearly every tree lived. In the fall of 1905 five bushels of walnuts were planted on the river bottom among scattering trees already in existence. It is expected that post cutting can be begun among the trees suitable for that purpose, within six years from the date of planting, after which there will be "a continual harvest with no seed-time," as the cultivation of several varieties is by coppice growth (or sprouting)." As Mr. Gerrish well remarks, this forestry work by the water board "will serve as an object lesson to the public along this, as yet, too little appreciated branch of economics."

A PROPOSED PLAN FOR EXCAVATING THE CULEBRA CUT.

The time in which the Panama Canal can be completed and opened to traffic depends on the time which will be required to complete the work of greatest magnitude, provided, of course, that the other lesser works are advanced simultaneously. This means, of course, that the great Culebra cut really governs the time for completion of the canal.

It will be apparent, therefore, that in order to expedite the completion of the canal, definite plans must be made to bring as rapidly as possible the largest possible number of steam shovels into operation, and at the same time to provide that these shovels shall not interfere with each other; that each shall be kept supplied with cars, and that the spoil from the various shovels shall be removed in such a manner that the trains of full and empty cars shall not conflict.

While serving as Chief Engineer of the Panama Canal Commission, Mr. John F. Wallace, who has had in his long connection with the Illinois Central R. R., large experience in steam shovel work, worked out a tentative plan for the sequence of operations in the Culebra cut, or, rather, in the half-mile section of that huge excavation where the elevation is greatest and the largest volume of material is to be removed. This

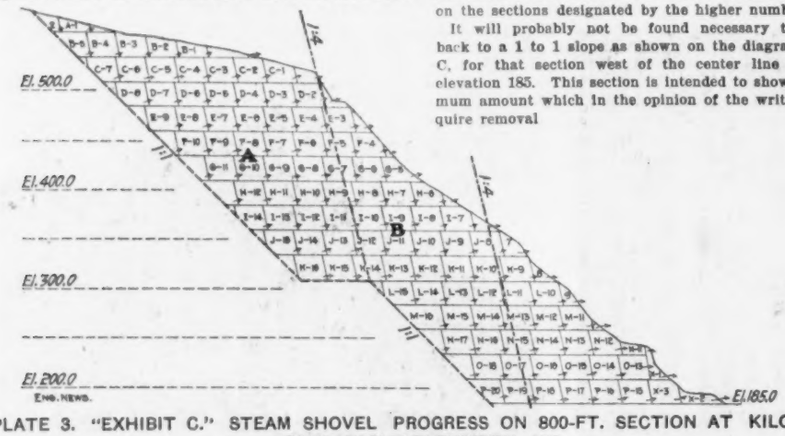


PLATE 3. "EXHIBIT C." STEAM SHOVEL PROGRESS ON 800-FT. SECTION AT KILOMETER 54.74, ABOVE ELEVATION 185.

(Section "A" and "B" may be eliminated provided the material will stand as indicated by dotted lines on slope 1 on 4.)
The entire contents of section above El. 185 can be taken out without interfering with the different phases below El. 185, as shown on Plate I.

plan was submitted by Mr. Wallace to the Board of Consulting Engineers, and is printed as one of the appendices to the Board's report. Through Mr. Wallace's courtesy we are enabled to present it herewith, as follows:

Herewith are seven diagrams, Exhibits A, B, C and D, illustrating a tentative method of working the mile in which the maximum excavation exists at Culebra:

Plate 1, Exhibit B, is a maximum cross-section at Kilometer 54.74, below elevation 185, and shows in numbers and colors the different phases of steam shovel progress.

Plate 2, Exhibit A, is a progress diagram showing the relative positions, horizontally, of the different steam shovels which may be installed at elevation 185 and below. It also shows the time of entering and the completion of each phase of the work.

Plate 3, Exhibit C, shows the A and B sections at Kilometer 54.74 on the line of the maximum cross-section above elevation -185 with the different phases in colors and numbers.

These diagrams are not put forward as an exact plan to be followed, but simply to illustrate the process of devising such a workable plan as the engineer in charge may desire, and should be regarded only as a tentative basic study.

The sections shown on Exhibit C, plate 3, and also that part of Exhibit A above elevation 185 as indicated by the letter "C" maintain the form shown on the exhibits only for a portion of the section. That part, however, of the average maximum section, Exhibit B, below elevation 185 will remain throughout the entire length of the mile section substantially as shown by the exhibit.

The phases above elevation 185, being masses "A," "B" and "C," Exhibits C and B, can and should be removed before the excavation of the central portion of the average maximum section below elevation 185 as they progress transversely to such an extent as to cause no interference, and they have therefore been given a separate system of numbers.

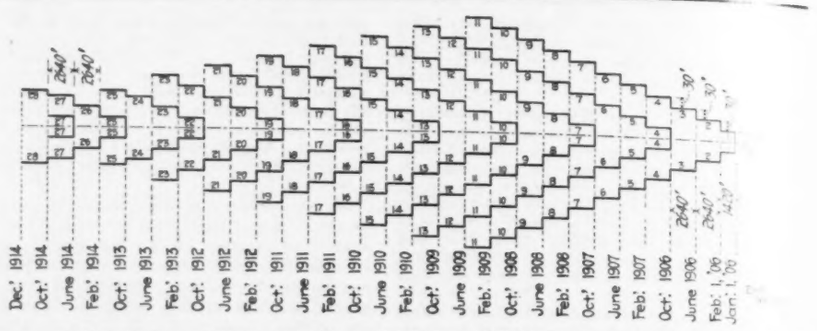


PLATE 2. "EXHIBIT A." STEAM SHOVEL PROGRESS DIAGRAM IN PLAN, SHOWING MAXIMUM AND MINIMUM NUMBER OF STEAM SHOVELS AT WORK IN THE DIFFERENT PHASES THROUGH 2,640 FT. (½ MILE).

(Numbers indicate shovels in different phases.
Calculations are based on a daily capacity per shovel of 1,000 cu. yds. and 20 working days per month.
Details of progress:
35.7 lin. ft. per day.
714 lin. ft. per month.
2,640 lin. ft. per 3.7 months.)
(Rate of ½ mile in 4 months used as basis of diagram.)

In accordance with this scheme it is presumed that the sections designated by the same letter or number should be removed approximately simultaneously on each half mile length and that the phases designated by the low numbers should of course be removed before commencing on the sections designated by the higher numbers.

It will probably not be found necessary to excavate back to a 1 to 1 slope as shown on the diagram, Exhibit C, for that section west of the center line and above elevation 185. This section is intended to show the maximum amount which in the opinion of the writer, will require removal

It is presumed that rock at the greatest depth of the central excavation will stand at a much steeper slope than shown in the diagrams. If this is the case, new slopes which will diminish the amount of excavation may be introduced at such points as the engineer in charge may deem advisable.

In the memorandum of quantities which has been furnished the writer, he notes that on the assumption of a bottom width of 200 ft. at an elevation of 40 ft. below sea level, with berms on each side of 50 ft. and side slopes of an average of 1 on 1 from that point to the top of the excavation, there exists approximately 1,200,000 cu. yds. of clay above an average of elevation of 290 ft. above sea level. This is the clay formation that has heretofore furnished the material for slides on the east side of the excavation and north of the maximum cutting at Culebra, which the writer commenced to remove during the dry season of 1904-5 while he occupied the position of Chief Engineer. The remainder of this material can be removed during the next two dry seasons at least, completing this portion of the work by April 1, 1907, without interference with the general scheme of excavation and far enough in advance thereof to remove any danger of slides from this class of material.

The material from an elevation of 290 ft. down to 185 ft. consists of shales and of a formation which, in the opinion of the writer, can be maintained in terrace form with intermediate slopes of 1 to 4.

Ten months will be available for the removal of the clay above an elevation of 290 ft., on the east side and north of Culebra summit, if done during the two dry seasons, or semi-dry seasons between December and May 1 of the two years before mentioned, during which time, on account of the dry season, steam shovels should easily average 20,000 cu. yds. of material per month per shovel, each shovel averaging 100,000 cu. yds. during each of the two dry seasons.

To accomplish this amount of work in this time would require the assignment of six shovels, provided they can work in this particular part of the cut satisfactorily for only five months in each of the two years.

However, the larger amount of sliding clay is in the vicinity of Cucaracha on the east side and at the south end of Culebra cut proper. This consists of a blanket of stiff clay, in which are embedded boulders, which lies upon a bed of fire clay or soap stone formation which exists on top of the solid rock. When saturated, this mass moves down towards the bed of the Rio Grande toward the central axis of the canal.

In the writer's opinion, special arrangements should be made for the removal of this superimposed sliding clay and it should be taken out in a quantity in excess of the cross-section requirements in that locality, and systematic arrangements should be perfected for working in this vicinity and taking out this material during the dry seasons in connection with a system of drainage so as to pre-

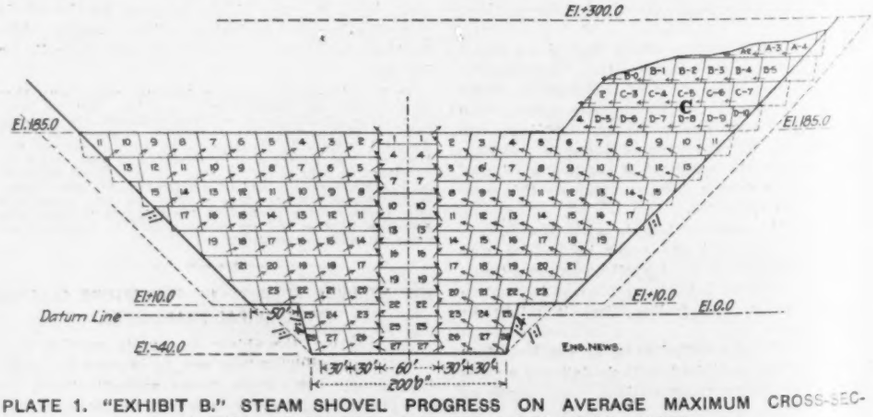


PLATE 1. "EXHIBIT B." STEAM SHOVEL PROGRESS ON AVERAGE MAXIMUM CROSS-SECTION OF CULEBRA CUT FOR A SEA LEVEL CANAL.

(End Sections of Benches 30 ft. x 25 ft.
Quantity per lin. ft. = 28 cu. yds.
Numbers indicate consecutive phases of shovel progress.
Maximum number of parallel shovels working simultaneously in ½ mile = 8.
Maximum number of parallel shovels working simultaneously in 1 mile = 16.)

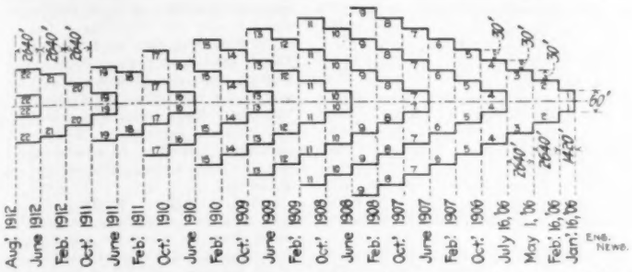


PLATE 8. PROGRESS DIAGRAM FOR LOCK CANAL WITH SUMMIT 60 FT. ABOVE SEA LEVEL, SHOWING MAXIMUM AND MINIMUM NUMBER OF STEAM SHOVELS AT WORK IN THE DIFFERENT PHASES, BASED ON SAME ASSUMPTIONS OTHERWISE AS PLATE 2.

vent it entering the canal prism and interfering with the work at the lower elevations. This, however, should be taken care of independently and irrespective of the rate of progress made on the maximum mile of excavation. About 3,000,000 yds. of this material now requires removal.

Exhibit A is a progress diagram which shows the relative positions of the different steam shovels which may be installed at elevation 185 and below. This series of shovels moving through the half mile will approximately complete the section except so far as it may require modifications to give the final slope. It will be noted from this diagram that the shovels will follow each other at intervals of one-half mile and will follow each other successively, those in advance passing out of the half-mile stretch, their functions being completed and others entering to take their places.

The shovels at the higher elevations will, of course, only have to proceed far enough to excavate the material on the plane on which they are at work. Taking the mile of deepest excavation, shovels would start in at the elevation of 185, which on the central line will only give a short distance to be excavated. The following shovels at a lower elevation will have a greater distance to move.

The shovels started at the higher elevation should work towards each other and when the phases at which they are at work are completed they will of course be eliminated and returned to work in other localities on other phases of the excavation.

The pilot excavators in the central cut should be pushed forward at each end of it at different elevations in order to afford the necessary drainage channels and to permit of the opening up of the work for the succeeding phases.

These diagrams were made on the basis of each shovel cutting out an area of 30 ft. in width by 25 ft. in height, with a daily capacity of 1,000 cu. yds., working twenty days in each month. On this basis each shovel advances 35.7 lin. ft. in one day and 714 lin. ft. in one month of twenty working days. The rate of progress for each half-mile phase has been considered to be four months.

Exhibit D, plates 1 to 4, inclusive, are diagrams showing a suggested arrangement of tracks and shovels covering the first five phases of the work below elevation 185.

The space between the different phases is one-half mile, which is considered sufficient to provide the necessary track space for the working of the shovels, each shovel being provided with two tracks, a running track and a track upon which the empty and loaded cars are placed. This distance between the phases is also such that there should be room enough for the necessary track adjustments as the work progresses.

Switching can be so arranged, whether one shift or more is worked in each 24 hours, so that each shovel will be supplied with a sufficient number of cars to last during the entire half shift, particularly if the long noon hour as at present is maintained, and tracks and cars should be provided of a capacity to permit of this being done.

It is of course understood that the progress diagram is only tentative and that the ability to carry the work out on these lines depends on many complicated factors, and the ability to work to a scheme of this character depends upon their proper coordination. Allowance should be made for the failure of various factors that properly coordinate. Should the average amount excavated by each shovel be less than 1,000 cu. yds. per day per month of 20 working days, additional time will of course be necessary. Should the average efficiency of the excavating machines be increased, the time will be shortened. It will be noted that the work on the maximum half-mile section can be completed in approximately nine years. This time would be lengthened or shortened, dependent upon the efficiency or inefficiency with which the work is handled.

According to this plan, three years would elapse from Jan. 1, 1906, before it would be necessary to employ the maximum average number of steam shovels on each section, and from 1909, eight shovels would be engaged on each half-mile section, which would make sixteen on each mile, being 80 steam shovels on the central heaviest five-mile section. The maximum number of shovels would be employed for eighteen months to two years, from which time the number necessary for the work would be gradually diminished.

The progress diagram in the plan of course does not show the shovels which would be at work removing material on the sides of Culebra proper above an elevation of 185 ft., which an analysis of the sectional diagram will show can easily be removed in such way as not to interfere with the progress below elevation 185, this maximum excavation practically being confined to one-half mile,

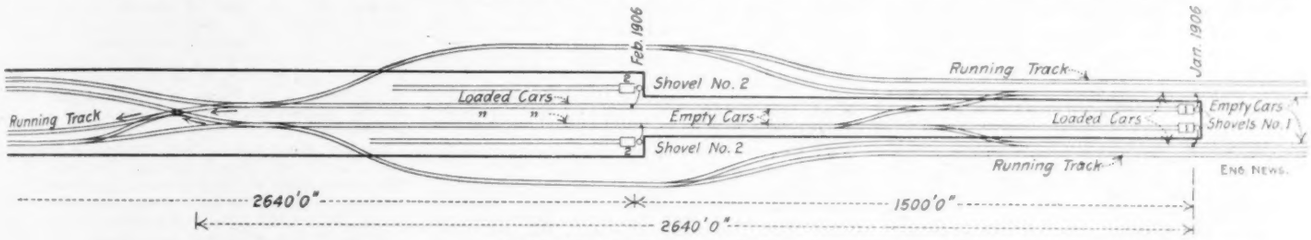


Plate 4. Phases Nos. 1 and 2.

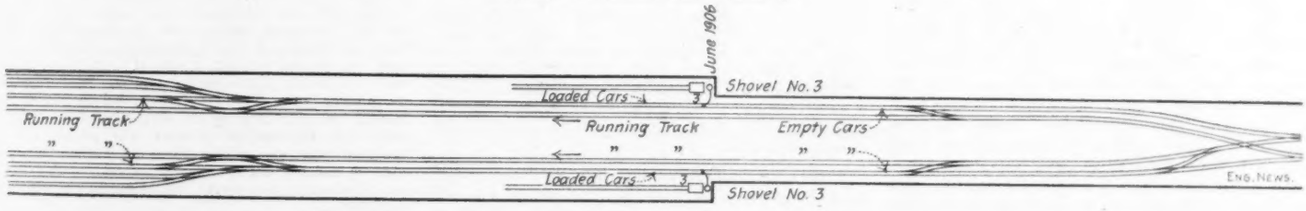


Plate 5. Phase No. 3.

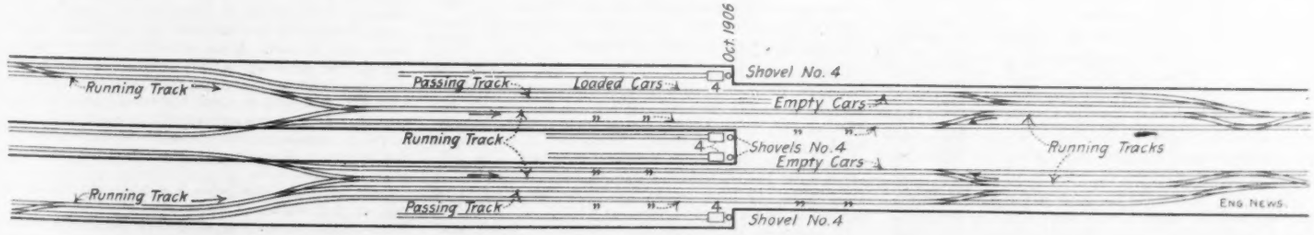


Plate 6. Phase No. 4.

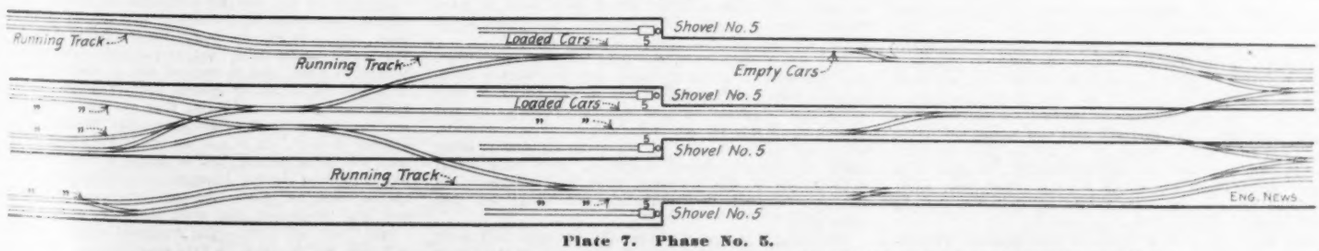


Plate 7. Phase No. 5.

PLATES 4, 5, 6, 7. "EXHIBIT D." PROPOSED TRACK ARRANGEMENTS IN CONNECTION WITH STEAM SHOVELS.

the crux of the work consisting of the sinking of the central excavation.

The efficiency of the whole work, as far as progress is concerned will depend largely upon the ability to keep the lowest central excavation in advance of the remainder. In the opinion of the writer it should be easily within the range of practicability to maintain the average results indicated in these diagrams, and so organize and control the force as to provide for an efficiency which will permit this to be done.

Few American contractors would be content to conduct this work only on a basis of an average of twenty working days in the month and only one shift per day, but would endeavor to form an organization which would yield a much higher rate of efficiency than shown by the conservative data used as a basis for these diagrams and which are considerably within the scope of attainable results.

Mr. Wallace also submitted a similar memorandum, outlining a plan for excavation on substantially identical lines for a lock canal with 60 ft. summit level. Plate 8, accompanying this memorandum, should be compared with Plate 2. It may be noted that Mr. Wallace finds by this method the time required for excavating the maximum half-mile section at Culebra to be 6½ years, as compared with 9 years for the sea-level canal.

TESTIMONY OF MR. JOHN F. WALLACE BEFORE THE SENATE COMMITTEE ON INTEROCEANIC CANALS.

On Feb. 5, 6 and 7 Mr. John F. Wallace, the former Chief Engineer of the Panama Canal Commission, gave testimony before the Senate Committee in charge of the Panama Canal investigation. The complete report of this testimony covers over 150 pages, and in the following we present a condensed abstract of some of the features of the testimony of most interest to engineers:

Mr. Wallace's appointment as Chief Engineer of the Canal Work in 1904 came to him from the Walker Commission unsolicited. In accepting it he stipulated that he was to be given a free hand in the conduct of the work under the general supervision of the Commission as a whole, and not of its individual members.

If I was simply to take charge of the work and conduct it according to the ordinary governmental methods or to the regulations of governmental departments, and use the methods which had always been used in the conduct of public works, my services would be of no avail at all; it would be much better to secure some person who was familiar with those methods and was accustomed to those ways. And I was particular to state that what I apprehended more than anything else was that each individual member would have his own ideas about special things, and that I would in a short time be endeavoring to serve seven masters instead of one.

Arriving on the Isthmus on June 28, 1904, Mr. Wallace found about 500 men at work in the Culebra cut, using hand drills and loading cars by hand, and excavating about 25,000 cu. yds. per month. Four parties of engineers had been organized for survey work, but had done practically nothing for lack of proper tools, drills, etc. Mr. Wallace first set about the repair of the hospital buildings and organized a building department to undertake the repair and construction of all sorts of buildings for the work. An organization for constructing a water supply and sewerage system was also immediately created. The plans for the Panama water supply were ready in August, 1904, and the work could have been completed and water brought into Panama by the following January except for the delay in procuring water pipe, the last of which was not delivered until May, 1905.

To my mind, what made the delay in the delivery of the pipe was this: A contract was made with an establishment at Birmingham, Ala. When the order was given for material, the Commission, not being familiar with the methods that are ordinarily used by manufacturers and railroads to expedite their deliveries, simply supposed that in some way or other that stuff would finally get down to the Isthmus. Now, in ordinary business, you have got to send your man to the factory, you have got to pound those men to see that they manufacture your pipe, and you have got to see that the railroad company furnishes cars, that the cars are loaded promptly, and you have got to follow it up and see that the railroads handle it and do not sidetrack it; because it is dead freight, that can lie at a place indefinitely, without any damage; you have got to see that it is shipped and loaded promptly and dispatched.

The pipe was sent by schooner from Mobile. The result, as I have arrived at it from my knowledge of the way those things are ordinarily conducted in business life, was that after the manufacturers got that order, they took their time to manufacture the pipe, and if they got a hurry order in from somebody else, that order was filled. The stuff was shipped on the railroad. That schooner could not leave until it got its cargo, and the train would start out of Birmingham with a lot of cars in it, and if the conductor had orders to pick up some freight that was more important, a car loaded with that pipe was set out, and, I presume in a few weeks that pipe was strung all the way along that railroad from Birmingham to Mobile. There was no one that was crowding it, you understand, finding where the cars were, and shoving the stuff along.

After weeks and weeks, that schooner was loaded at Mobile, and it took it three or four weeks to get to the Isthmus. When it came down there (along in January sometime the first schooner arrived), we found that they were depending upon that schooner unloading and getting back to Mobile before we could get any more of that pipe. In the meantime I could not get any information. I cabled the Commission, asked them to expedite it, and suggested that they send me at least some of that pipe by steamer, instead of by schooner. Not being able to know when it would come, and expecting it right along, I had my trenches dug, and they were filling up, caving in; and I wanted to get the pipe in, so as to give those people the benefit of a water supply in the dry season.

Mr. Wallace's repeated appeals to secure the more prompt forwarding of the water pipe brought finally a letter from Admiral Walker, Chairman of the Commission, hinting that he had better not spend so much money in cabling!

The building department was greatly delayed by the non-arrival of lumber. In order to divide the purchases among different sections of the country, the Commission cut up its orders, obtaining some lumber from Louisiana, some from Oregon, some from California, and so on.

The way material was obtained was this: A man in my department, say a division engineer, that desired some material, say a dozen shovels, would make out that requisition, and it finally came to my office; and when I approved of his having them it went to this Mr. Tobey (Chief of the Material and Supplies Department). If the supplies were on the Isthmus Mr. Tobey delivered him the goods. If they were not on the Isthmus, he took all of his requisitions that he had received probably during that day, it might be for a dozen shovels, a box of pens, or a million feet of lumber, or a coil of rope, or a lot of coal, or a hundred barrels of cement—it made no difference what it was—those were all grouped on a requisition which went to the Commission. They took that requisition and passed it around among themselves.

They would mull over it, and then it would go to the clerk of department that had charge of it, and they would make a reseparation of the articles on the requisition, and would ask for bids under another classification or grouping. The result was that the original requisition number was entirely obliterated in this transaction, and finally, months and months afterwards, that stuff would come down to the Isthmus, and there was no way of knowing what particular requisition it was to apply on at all. It came there, and if one of my men happened to be at that storehouse and saw stuff that he had asked for two months before, and he was bright and energetic, he would get hold of that stuff, whereas a man having charge of work where the material was more urgently needed, who was not quite so energetic, although he had asked for it two months before, would not get it. I would find that things would happen in that way, and that there would be the same story repeated about not getting requisitions filled, and things were getting into an inextricable tangle.

A very interesting part of Mr. Wallace's testimony related to his work in the Culebra cut. It has been alleged that the work conducted there under his administration was not well planned or worth while for the result accomplished. We print, therefore, Mr. Wallace's statement concerning this quite fully, as follows:

I endeavored to balance the force. For instance, we could not put all our men on our buildings, because we did not have the material. We could not put all our men on our water supply and sewerage work, because we did not have the material. These two or three thousand men that were doing sanitary work had to be provided with houses, and we had to have carpenters to build them. In other words, the whole thing had to be carried on as a certain harmonious whole.

To commence at Culebra, for instance, we found, as I said before, about 500 men there at work. To have stopped that work entirely would have been to have thrown those men out of employment. They were living there, a great many of them with their families.

Here was a start made, and here was an organization, and the work was going ahead, and the Walker Commission and myself thought that it was policy to continue that organization and gradually enlarge it and expand it. While we had to change the French methods, while we were not able to get materials and supplies there in properly related quantities, other than steam shovels, yet it was economy, from my standpoint, to gradually expand that operation and never let that work stop.

These men were being trained all the time; they were being disciplined; we were teaching them, and they were learning new ways of doing things—learning [illegible] methods—and it was, you might say, a training school.

The first thing that we attempted to do there was this: The French were digging holes along that [illegible] cut, hauling the stuff out and piling it in ravines in the side of the mountains and hauling it up grade by steam. The first thing I tried to do was to shape that work up and cut these barriers out in order to get drainage. The next thing I tried to do was to take this blanket of wet clay that was sliding down off the top and get that out of the way.

I had a regular system outlined in my mind for that work, and everything that was being done there was being done on a certain definite plan. Of course, my subordinates did not know what that plan was. A great many features of it I had never formulated in writing, because up to the time I left there it was unnecessary that I should. I wanted to give that work a full year's thought and study and experience before I committed myself to a written expression of what I considered my views as to the best way to handle it as to methods and arrangement and everything; and that is what I intended to put in my annual report, if I had been permitted to make one.

SENATOR HOPKINS.—The work that you were doing there was both in the dry and the rainy season; so that you were the better prepared then to make estimates as to the cost of excavation in both seasons by reason of the work that you did?

MR. WALLACE.—Yes, sir. The work extended over a full complete year, and we tried thus to keep very close tab on our costs at every step.

In the modern management of railroads and manufacturing plants efficient results are obtained by the ability to tell definitely the relative efficiency of men, methods, machinery, and appliances by some unit of measure. For instance, on a steam railroad the unit of measure is what it costs per ton per mile to handle freight. In the case of a manufacturing plant, what it costs to manufacture an article, and the cost of every step in the manufacture of that article, is the thing that determines the efficiency of the men and the machinery and the methods that are used.

That is exactly what I tried to do down there. For instance, the cubic yard of material in that cut was my raw material. The cubic yard of material finally disposed of was my finished, manufactured product. I wanted to know what it cost to mine that material, what it cost to load it, what it cost to transport it, what it cost to dump it and dispose of it, what it cost to keep up the tracks—what every individual step cost, you understand.

The first object was to train the men to keep those costs, and to keep them accurately. That was training. The second object was to determine the efficiency of the machinery. We put to work French excavators, for instance, that we had there; and I wanted to know, before I destroyed that machinery or scrapped it or bought American machinery, how much per yard it cost to do the work with that machinery. I knew what I could do with the steam shovel, and the comparison would show me whether it was economical to throw that stuff away or try and keep it. I wanted to get the information that would protect myself and the Isthmian Canal Commission when we were investigated by you gentlemen or the gentlemen on the other side of the building here, and they wanted to know why we threw away machinery that cost the French twenty-five or thirty millions of dollars; and this process of cost keeping would have demonstrated in dollars and cents the correctness of that policy.

Another thing that it did was this: What it cost each group of men to mine a cubic yard compared their efficiency. What it cost to load with every different steam shovel compared the efficiency of one shovel and one crew with another. What it cost to transport the stuff showed the efficiency of the various men in the transportation departments. And that unit of efficiency was such that if it had been continued and carried out, properly analyzed and properly applied, it would give the man in charge definite information as to the comparative value and efficiency of every method, every man and every appliance on that work.

I did not claim that when I got through, because the cost of that work was an average of 43 cts. a yard in March, that 43 cts. was what that work could be done for. When we came to May, and it went up to the vicinity of 80 cts., and my men came to me and wanted to stop because they thought it was not economical, I said, "No, it is not the fact;" for if I knew what made this work cost 80 cts. a yard, it was just as important as it was to know that it cost 43 cts. in the dry season. If it was the 13 ins. of rainfall that we had in May that made that average of 80 cts., that was one thing. If it was the change to the eight-hour-a-day basis, there was another element. If it was our using French machinery that was being derailed ten or fifteen or twenty times a day, that was another element. In other words, it was not the cost, but it was the conditions under which that cost was determined, that made those figures of value.

SENATOR HOPKINS.—You developed enough there, did you not, Mr. Wallace, to determine that the use of the

French machinery was not an economical way of constructing the canal?

MR. WALLACE.—Yes; yes. The reason I have gone into such a prolix explanation of this cost business is because I have been publicly criticized by men high in authority because, it was said, I was misleading myself; and I wanted simply to show you gentlemen that the process was a proper one, and that it was thoroughly scientific. The day has gone by when a great, large piece of work can be properly supervised by somebody going around and saying to this man, "Do this," and to that man, "Do the other thing." You must have a knowledge of the results of every man to determine whether or not that man is doing his work properly.

SENATOR DRYDEN.—Had you at the time of your resignation fully developed and completed your organization and your investigations?

MR. WALLACE.—At that time I had enough technical data in my mind to enable the board of consulting engineers or the Commission to determine the general questions of plan. I had enough data to enable me to make a determination in my own mind of what I considered the best methods to use, although of course none of these were actually formulated.

SENATOR DRYDEN.—Do you know whether your successors have continued the plan which they inherited from you in this organization?

MR. WALLACE.—No, sir; I do not, except in a general way. I judge this, though, that it is hard enough to get men to do what you want them to do even if the power above them thoroughly understands that they can do it and are required to do it. When they are at work on a system that is only supported in a half-hearted way, or the utility of which has been criticised by others higher in authority, it is hardly fair to expect that those men would exercise the same care and the same accuracy in that work as they would otherwise.

To what extent these costs are kept up or not, I do not know. I knew they went very high immediately after I left there; and when Mr. Stevens arrived on the Isthmus, about the 1st of August, I have been informed that he found things in a very demoralized condition.

Now, that was not due to my resignation. It was due to my treatment when I resigned, and also resulted from the fact that as the men that I left on that Isthmus had seen their chief discredited in a way, and knew that a successor was to fill his position that had been selected with an idea that everything that I had done was subject to criticism, there was not a man there that felt his place was secure, and the result was that there was naturally complete demoralization. That would happen anywhere.

In the month of July, 1904, the average cost was 64½ cts. per cu. yd., for excavation and disposal.

SENATOR MORGAN.—In earth, not in rock?

MR. WALLACE.—No; that was the rock and earth together. That is the average. In August it was 50 cts.; in September, 56; in October it was 52; in November, 47; in December, 50; in January, 1905, 48; in February, 46½; in March, 43; in April, 52; in May, 84; in June, $1.02; in July, $1.03; in August, $1.54; in September, $1.44.

It made the average cost per cu. yd. about 71 cts.; but the average cost for the twelve months under my jurisdiction there was, I think, 58 cts.

A considerable part of Mr. Wallace's testimony related to the circumstances connected with his resignation from the work. We published in our issue of July 6 last Mr. Wallace's statement regarding the causes which led to his resignation. Some additional facts of interest were brought out in the testimony regarding the motives which prompted him to present his resignation. At the outset Mr. Wallace presented the following statement to the committee:

"I take it for granted you are familiar with the violent attack upon me which Secretary Taft and Mr. Cromwell gave to the newspapers last June, and my first words, therefore must be to ask you to suspend your judgment upon the justice of that attack until after I have had an opportunity to explain to you why I think it was absolutely uncalled for and unjustifiable.

"I will speak of it with as little warmth as possible, seeing that it might have prevented me from even earning bread for myself and those dependent upon me; and remembering also that after I had spent more than thirty years in an honorable calling without a word ever uttered against my good name, I suddenly found myself placarded throughout the country as utterly lacking in personal and professional honor. Now, my honor is as dear to me as that of Secretary Taft's and Mr. Cromwell's could be to them, and I have kept it quite as unsullied.

The only basis pretended for this attack upon me was a difference of opinion between Secretary Taft and Mr. Cromwell on the one side and myself on the other as to my right to decide for myself when I thought the welfare of the enterprise and my own welfare justified me in resigning my position.

"My appointment named no length of time I was to hold it, and I was liable to be dismissed at any moment by telegraph. Such being the case, I believed then, and believe now, it was my undoubted personal right—and I believe every reputable engineer must be of the same opinion—to resign it whenever I thought it necessary to do so; provided, of course, that I took abundant care that the work in my charge would suffer no harm by my resignation.

"I had taken every precaution and made every necessary arrangement to that end before leaving the Isthmus, and, having done so, I never dreamed that anybody would dispute my right, legal or moral, to ask that my successor should be appointed when it was convenient to do so.

"I came north to have a private talk with Secretary Taft, in which I intended to fully explain the real reasons for my resignation, to put myself at his disposal, to assist him in securing, if he desired, my successor before he started on his trip, and to satisfy him that Mr. Dauchy, whom I had left in charge, was just as competent as I was to conduct such work as could wisely be done until Congress decided upon the type of canal.

"The opportunity for this private talk was denied me, and when I found myself confronted with both Secretary Taft and Mr. Cromwell I contented myself with giving as a reason for resigning, the larger compensation I hoped to secure in another employment. I did so because I assumed that reason would be accepted as sufficient for the time being and avoid the discussion of other reasons in the presence of Mr. Cromwell. But I soon found that they had both come to the interview determined to discredit me and if possible to destroy my reputation, simply because I insisted upon resigning when I had become convinced some other man in my place could render better service to the enterprise under the conditions which with my concurrence had been created."

In the testimony which followed some of the controlling reasons influencing Mr. Wallace to decide upon his resignation were brought out, as follows:

SENATOR MORGAN.—Had you made up your mind before you left the Isthmus to come to New York, that you intended to offer your rsignation as chief engineer?

MR. WALLACE.—Yes, Sir.

SENATOR MORGAN.—And also as Commissioner?

MR. WALLACE.—Yes, sir; no, not as Commissioner; well, that is, on certain contingencies. I had made up my mind that under existing conditions the proper course for me to pursue was to offer my resignation. Whether I would insist upon that or not was dependent entirely upon the result of the prospective interview which I expected to have with the Secretary after my arrival here. The way I had figured it out in my own mind was that under the circumstances the greatest service I could render to the Government was through being in a position where my counsel and advice would be available as long as there would be any necessity or demand for it. I felt that the position in which I was being placed as chief engineer—that is, having my duties confined to the merely technical work of superintending the work on the Isthmus was of very small moment compared to the value that I might possess to the Government and the Administration in regard to my views and opinions and general advice as Commissioner at that time.

The situation was this: Nothing could be done, except a small amount of work—preparatory work and some experimental work—until the next dry season came on, and general plans could not be made for the conduct of the work until Congress decided on the type of the canal. The man that I had left in charge there, who was my next assistant (Mr. Dauchy), was a man who had been chief engineer of the Chicago, Rock Island & Pacific Ry. system, a system fully as large as, if not larger than, the Illinois Central Railroad; a man of almost my own years; a man who was just as well qualified as I was to hold the work in hand and keep the organization going—to train it and drill it—and to continue the preparatory work. My own idea was that I could perform the best service by letting Mr. Dauchy follow me on the Isthmus there, and then by preparing this annual report, preparing the data to submit to this advisory board, to assist that advisory board in furnishing it information; and later on, if it was necessary, by appearing before committees in either branch of Congress during this winter, to advise and help them to analyze these reports, and so on. I felt that in doing those things I would be furnishing the best service that I could to the United States Government. I made a good many mistakes in my attitude toward that work, mainly for the reason that I was enthusiastic in regard to it. That is, I became so as I studied it, and I felt as if nothing should stand in the way of its success. I felt that the Secretary of War and Mr. Cromwell failed to appreciate the character of work that I was best able to give, and when a new chairman of the Commission was appointed I tried to accept that position; I was very grateful to the Secretary for the change, because I felt that in appointing me on the Commission and on the executive committee he was trying to shape the work up in a proper way. But later on, and particularly after I had sailed for the Isthmus and gone back there, to my mind there appeared an indication upon the part of the chairman to dominate the entire work and to place me in a secondary position.

SENATOR MORGAN.—Who was the chairman?

MR. WALLACE.—Mr. Shonts; and I felt that I could not give the best service to the work in that position.

SENATOR MORGAN.—Was it your purpose, then, in leaving there, to disconnect yourself at all events and absolutely from all connection with the Panama Canal construction?

MR. WALLACE.—I do not like to say that it was my absolute purpose; but it was what I desired to do, and I desired to discuss it with the Secretary, and I desired to suggest that course to him.

Now, if you will let me explain, Senator, my position was this: After mature thought in going down there the last time I felt that the relations between myself and Mr. Shonts and between myself and Mr. Cromwell would in a short time arrive at a point where I felt that friction would be engendered which would be detrimental to the success of the work, and would be embarrassing to the Administration; and I did not think that it was fair to let that situation mature. I thought it was better for the work for me to come north and have a plain talk with the Secretary, and if he felt the same way that I did for him to relieve me and to put some man in there (of whom there are a great number in this country) that could work in a subordinate position to Mr. Shonts, and who was willing to be in a position where he would be dictated to and under the control of the work, as Mr. Cromwell was——

SENATOR MORGAN.—I can well understand how you would desire to approach the Secretary to reach some understanding in regard to the opinions (which seemed to be conflicting) of yourself and Mr. Shonts concerning the conduct of affairs there, but I do not see why Mr. Cromwell had anything to do with it. Will you please explain that?

MR. WALLACE.—To show you Mr. Cromwell's connection with the work, Senator, I will say that in the statement which the Secretary of War made public after my interview with him, he uses this expression:

"There were present the Secretary of War, Mr. Wallace and Mr. Cromwell, who for some time had been charged by the President and the Secretary of War with general advisory duties in all Panama Canal affairs."

SENATOR MORGAN.—During that interview between you and Mr. Cromwell and Secretary Taft was it intimated to you, or did you intimate, that you were to receive a greater compensation in some arrangement that you had either completed or expected to complete with another business or another line of business?

MR. WALLACE.—I do not recollect the statement that I made. I think I said to the Secretary that I had an offer that I would like to accept that would give me a compensation of practically double what I was receiving, and that when I first received it I had hesitated, and in the correspondence that went backward and forward afterwards the intimation was given to me that it would be increased, if necessary. One of my motives in telling him that was to give him an apparent reason for my leaving, and the other one was that I did not want him to think that I was after any pecuniary consideration. In other words, I wanted to disabuse his mind of any idea that I had come up here to try to get him to increase my salary, because I have never asked any employer in the last thirty years to advance my salary in any position that I have ever held.

I may have been wrong in it, but I supposed an intimation of the offer I had received would be more acceptable to him than any other reason that I could give him, on account of Mr. Morton's having laid down his duties as Secretary of the Navy and accepted a more lucrative position, and Mr. Day's having laid down his duties in the prosecution of the trusts, and things of that sort, and that seemed to "go" satisfactorily. I may have been wrong in intimating anything like that.

I want to say right here, however, that I had not accepted that position then and that I have not accepted it since; and that before I had the interview with the Secretary, I told the parties that had made the proposition to me that, while their proposition was satisfactory in a way, I did not propose to go any further with them until I could find out whether or not I could make a satisfactory arrangement with the Secretary of War to accept my resignation and to make some arrangement by which my leaving would not endanger the work or embarrass the Administration.

SENATOR MORGAN.—Now, Mr. Wallace, why did you not want to go back as chief engineer?

MR. WALLACE.—Well, under the Executive order I was equally responsible as a member of the executive committee on the Isthmus with Mr. Shonts and Mr. Magoon, and under the interpretation that Mr. Shonts put on his arrangement with the President—that was a verbal arrangement which I understand he had with the President—he was to absolutely dominate that work.

SENATOR MORGAN.—To have a "free hand," as the expression is?

MR. WALLACE.—Yes, sir; to have a free hand. And I was placed in the secondary position of being subordinate to him. I felt that, without any egotism at all, I was much better qualified to conduct that work than he

was. I felt that he had not had the experience either in a business way or a professional way, and that he was not as well qualified as myself, either in a business way or as an administrator or as an executor of that work.

SENATOR MORGAN.—He is not an engineer?

MR. WALLACE.—He is not an engineer at all, you understand. I felt this: That with the outline that I had made of my ideas of that work to the original Walker Commission I was to be practically what you might call director-general of that work; that while my headquarters were to be on the Isthmus, still it was thoroughly understood that I was not to be dominated by any single individual that would come between the Administration and myself. I felt that I could not give loyal service in that position, and I felt that it would be much better for me to sacrifice my ambitions, which were practically boundless, as far as the engineering work was concerned, which would have been the crowning effort of my professional career, if I could have remained in the work. I felt that it was better for that work for me to go even to the extent of sacrificing those ambitions rather than to stay there in a position in which I had been humiliated and in which I would have felt that it was my duty to disobey orders that I might receive, or create friction which would cause lack of harmony and disturbance. I felt that it was my duty to get out, particularly when there was so many men that could be employed that were just as competent as I was to occupy a position of subordination.

SENATOR MORGAN.—Then, holding the position of engineer in chief under the Commission, and also of chairman of the committee of engineers, you were not disposed to take orders from Mr. Shonts as to your conduct in conducting the engineering of that enterprise, unless those orders came from the Commission?

MR. WALLACE.—No, sir.

SENATOR MORGAN.—That was your attitude?

MR. WALLACE.—Yes, sir; in other words, I considered, and I think the wording of the executive order that outlined that organization will bear me out, that there was not anything in that to give Mr. Shonts any more domination over myself or Mr. Magoon than his vote would entitle him to—either his vote as a member of the executive committee, having the casting vote, or his vote as a member of the Isthmian Canal Commission, he being chairman and having the casting vote, in case of disagreement.

SENATOR MORGAN.—Was it any part of your purpose in coming up to New York to see the Secretary of War, to ascertain whether the free hand that had been given to Mr. Shonts meant all that he claimed that it did?

MR. WALLACE.—That was something that I wanted to discuss with him.

SENATOR MORGAN.—You did not want anybody put over you except the Commission?

MR. WALLACE.—No, sir. Then there is another thing that I had in my mind, and that was this: I wanted to discuss with him Mr. Cromwell's relation to the work. Mr. Cromwell was an officer of the Panama Railroad and Steamship Line, and Mr. Cromwell, to my mind, seemed to be the controlling force that dominated the policy of that railroad, and he had already performed several acts in that connection that did not strike me as acts that lined up with what I thought was the proper way to handle that property.

SENATOR MORGAN.—It was the affairs of the Canal Commission and the railroad that he was attempting to control and dominate?

MR. WALLACE.—I had one interview with him, in which he undertook to practically tell me the character of men I ought to hire, and matters connected with some of my appointments; and that I resented quite strongly at the time. But it was not until after I had gone back and I commenced to think over that and think what it meant, that I realized that he meant to impress upon me the fact—that is, by implication—that it was something more than a suggestion, and that on account of his influence with the Secretary I ought to be guided by his suggestions, and that they should be authoritative, that the full effect of it struck me; but the substance of it all was simply this, I felt that my position was rapidly becoming untenable, and I felt that in my expression of gratification at the change in organization I had made a mistake, and that I ought to have raised the question then, and I feel now that it would have been much better if I had remonstrated at the very start.

SENATOR HOPKINS.—You mean at the time of the reorganization of the Commission?

MR. WALLACE.—Yes, sir. But at the time I was in the States I wanted to try it. The situation was so much better than it had been before, the organization was on better lines, and I made up my mind then that I would cheerfully try to get along with Mr. Shonts and that I would wait until he committed some overt act in directing me, and then let him raise the issue; and the same way with Mr. Cromwell. I did everything I could to keep on good terms with him. It was impressed on my mind that he was a dangerous man, and that it might be that his motives were of the utmost purity; that it might be, on account of his great personal wealth, that what he was trying to do was to perform a patriotic duty gratuitously, and that I might misjudge him.

SENATOR MORGAN.—If I catch your meaning, and I think I do, part of your office up here was to shake Mr. Cromwell off your shoulders?

MR. WALLACE.—Yes, sir; you have caught the meaning.

SENATOR MORGAN.—Did you feel that that was necessary to the proper and successful prosecution of the work there?

MR. WALLACE.—I did not want to do him any injustice. But it did not strike me that his relations with the work were such as were most desirable.

SENATOR MORGAN.—In what direction is he dangerous?

MR. WALLACE.—I suggested that he may be perfectly harmless, but it struck me that from his relation to the work, as being the man that brought about the sale of the Panama Canal, that assisted in the Panama revolution, that acted as fiscal agent of the Panama Government in making its investments, that is carried on the Panama diplomatic list as one of its members, is a director in the Panama Railroad, an advisor to the Secretary, a stockholder in a public utility company that was on the Isthmus, I felt that a man that was mixed up in so many things was liable to have his ideas perverted, and might some time or other advise the wrong thing, or do the wrong thing, which, if the executive committee that controlled the Isthmian Canal should follow his advice and follow his instructions, might possibly lead to scandal.

SENATOR MORGAN.—I take it from what you say that your apprehension of his capacity for doing dangerous things consisted mostly in the fact that he was on the make and had good opportunities on the Isthmus to make money out of the Government?

MR. WALLACE.—One of the things that struck me most peculiarly about it was that when I got into the Panama Railroad office I was looking over their reports and I found that the last year that the Panama Railroad was owned by the French company, which owned 99% of its stock, they declared a dividend of over $100,000 more than they had earned; and that after the declaration of that dividend they sold bonds in their treasury to make ordinary repairs or rebuild their steamships, which should have been rebuilt out of the earnings of the company; and it looked to me as if for counsel to advise that proceeding (which to my mind was practically taking that much money that belonged to the United States Government and putting it into the pockets of the holders—I mean, of the owners of the New Panama Canal Company) bordered on the line of "high finance."

SENATOR MORGAN.—Otherwise translated "graft?"

MR. WALLACE.—Yes, sir.

Regarding Mr. Stevens' statement as to the troubles experienced in using the old French tracks, Mr. Wallace said:

I did not want to imply that it was anyone's fault on the Isthmus now, that the costs of excavation at Culebra ran up after the 1st of July. They commenced to climb in May and June, due to a combination of causes that had not existed before. The principal cause was, of course, the eight-hour day. The next was the fact that everything came down there in an unbalanced way. For instance, we would want so many steam shovels, so much tracking, so many engines, so many cars, and so many steam-shovel men, and so many firemen, and all that sort of thing, and we might get a whole lot of one class of men and none of the other to go with them.

Then the main feature, and the feature that I judge has given Mr. Stevens the most trouble, was this:

We were never able in the dry season, when we should have done it, to locate our tracks properly for the conduct of the work during the wet season, because we did not get the track material and the labor in spite of the utmost endeavor to get that material. The result was that the only tracks we had to do business on were the old French tracks, which we tried to restore, and now and then we would connect up a new piece of track. We dug out and repaired, I should judge, about 35 miles of tracks. That was one reason why Mr. Stevens, not having had any conversation with me before he went down there, and not being able to avail himself of any of my ideas about the work, thought there was not any system in view, because we had to do what we could with those tracks that were already there.

Concerning the character of the material known as indurated clay, which may be used as foundation for important structures on the Isthmus, the following is of especial interest:

SENATOR MORGAN.—Did you make an examination—a physical test—of the softer parts of this material that you found at various places along this line of borings, to see what effect the alternation of air and water would have upon it—whether it would dissolve it?

MR. WALLACE.—I observed that very closely, and the best example I saw of that was the slopes that had been exposed there for years, that the French cut down partially; and I found it in wells that they had dug, sample wells, which had stood perpendicular for years. Down near Panama, near the foot of Ancon Hill, there is a place where I saw a ditch that was about 17 or 18 ft. deep, about 3 ft. in diameter, that was cut through this indurated clay, that had stood there for years and years without enough of the stuff falling down into it to fill it up. It was used to convey water from a spring to a still on the Dias place. That had been there for years and years.

LABOR PROBLEMS ON THE ISTHMUS.

SENATOR KITTREDGE.—I would like to hear your views, Mr. Wallace, on the subject of the eight-hour law.

MR. WALLACE.—My preferences, of [illegible] would have been for the continuation of the ten- [illegible]day. The question of eight hours, however, was fo[illegible]us; and along in, I think, February, there was a [illegible]t made to organize our men into a federation of [illegible] When I commenced to examine into that I had [illegible]d that I was protected by a formal resolution of th[illegible]er Commission requiring me to work the men [illegible]; but I found that my instructions, instead of bei[illegible]atter of record, were verbal and were more in the [illegible]e of not being permitted to change from ten hours [illegible] was the custom. That was the way we came to [illegible] the question of the eight-hour day; and it was [illegible]l by the Attorney General some months later that [illegible]ight-hour law applied there, and we put it in force.

SENATOR KITTREDGE.—What would you advise in reference to its continuance?

MR. WALLACE.—That is a very serious [illegible]tion. At first blush it seemed to me as if it meant a [illegible] increase in the cost of the work; but I now doubt that it would make some increase in the cost; possibly [illegible] 15%. I do not think it would affect it to the extent of the whole amount. What I do think is that a provision should be made to make it flexible and to make the work of an emergency nature, so that the engineer in charge of the work can determine what classes of men he wants to work eight hours and what classes ten hours. The progress of the work will depend upon how continuously the steam shovels can be served with cars. That switching has got to be done in between, before the men go to work and after the men quit work. The men have got to be taken to and from their places of work by these train crews, and certain classes of your men have got to work ten hours in order that others may work eight. I consider it absolutely impracticable to make a law that will apply the eight-hour law to the gold men and permit the natives and the foreigners and the aliens and the silver men to work ten hours.

SENATOR KNOX.—But if the eight-hour law were abolished altogether, and the hours of labor were to be fixed by the person having charge down there according to the circumstances, it would relieve the situation, would it not?

MR. WALLACE.—That is the ideal situation; there is not any doubt at all about that.

SENATOR HOPKINS.—Mr. Wallace, the labor down there will not be American labor, such as we have here in the States, will it?

MR. WALLACE.—I suppose about 10% of them will be Americans. That will consist of foremen in various capacities, trainmen, enginemen, cranesmen on your steam shovels and on the handling machinery, mechanics in your shops, boiler makers, blacksmiths, carpenters, etc. I do not presume you will find any Americans actually at work with a pick and a shovel, you understand, but as to the intelligent labor, there will be a great many Americans scattered through it, and the intelligent labor necessary to handle the machinery will eventually be practically all Americans.

SENATOR KITTREDGE.—As I understand, you believe that Congress should give a free hand in regard to hours of labor and character of labor and its selection?

MR. WALLACE.—I think that Mr. Stevens, or whoever you put in charge there, should be supported to the utmost, and that he should have just as few restrictions placed on him as possible in what he pays his labor, in the character of it, where he gets it, and the hours that he works it. The only way you can do your work down there successfully is to put in the hands of a pure, absolute despot, and hold his hands up, and keep the wolves off his back.

SENATOR SIMMONS.—If eight hours is a reasonable day's work in this country, would not eight hours be just as reasonable a day's work down there?

MR. WALLACE.—A man can not stand as much physical exertion there as he can here; and, whether he is white or black, American or negro, he can not give the same quality of labor there continuously that he can here.

SENATOR MORGAN.—Mr. Wallace, if the eight-hour law was extended to all labor in the Isthmus, when you came to let your contracts (if you do contract for the building of the canal) would it not make a very great increase in the amounts bid for the work, because of the existence of the eight-hour law?

MR. WALLACE.—Yes. In the first place, it will make an increase in your bids. Contractors will consider it, as a rule, about 20% more expensive to do the work; but that is not all. If they are subject to the eight-hour law, and are subject to a fine whenever they permit or require a man to work more than eight hours, they will put even a greater percentage on it than that, for this reason: If you are doing work on the basis of the ten-hour day, and you want to hurry a certain track through, and want to pay the men overtime and work them eleven or twelve hours for two or three days (which the men are perfectly willing to do if they get the extra payment for it), you can get that piece of work out of the way. But under the eight-hour law you can not work a man two hours more unless you are able to show that there is an actual emergency existing that requires it in that particular case; and every time you do it there is a chance for a

controversy between the foreman and the men. The foreman will say, "This is not necessary," and they will refuse it, and take it up, and claim that it is a violation of law.

SOME REASONS FOR THE INEFFICIENCY OF GOVERNMENT WORK.

I have cited just a few instances to illustrate the delay in getting material and how it hampered the work. There is one thing, however, which I think is quite as important, if not more so, than that of material, and that illustrates what really is the cause of what we call in general terms "red tape." In other words, as I see it from my standpoint I call "red tape" is simply system gone to seed; it is the disposition of chief clerks and officers to be so wedded to doing things in a certain way that they look on the way of doing it as more important than the thing to be accomplished.

The trouble about the disbursement of Government funds is this: For a hundred years you have built up a series of checks on governmental disbursements with the view of preventing waste. That is all right in itself, but the tendency of the whole process has been to retard payments. I will cite just a few examples of the way that affects constructive work like this.

When I tried to bring in labor there I found that we could not advance money to our labor agents to even pay their own expenses or to pay the transportation of the labor. I found that when we undertook to do things and then prepared a voucher in the regular way, and that voucher got to the disbursing officer who was to pay the money, he constituted himself judge and jury and everything else, and claimed that he was in a position to interpret the meaning of the Spooner bill, under which we were working. And if he thought that specific authority had not been given in that bill to spend money for every specific thing—not the specific amounts, but amounts for certain specific purposes—he would not pay that money; and that tied everything right up until we could take it up with Washington.

I had a talk with that man. He was a young lieutenant in the Navy. I would say: "Why don't you take an interest in this work and try and find some way to help me to do it? It seems that you and your clerks are trying to find ways to hinder it." "Well," he said, "Mr. Wallace, suppose I pay this bill for the transportation of these men here, and it goes through, and six months from now or a year from now, in checking my accounts in the Treasury Department they claim that that was unauthorized—that money will be charged back against my personal account or my bondsmen."

What bothered me about it was this: In that particular case one or two of the first bills for that transportation were paid. Then some clerk in his office raised the question that he might be getting into trouble, and the next one he held up. The result was that the steamship captain got out of that port without getting his money, and then all the steamship captains of that line refused to bring any more labor to the Isthmus until its transportation was paid in advance, and that we could not do.

That was not this disbursing officer's fault. It was the fault of the system. The whole system is based on what we call "audit after payment." In other words, every disbursing officer watches these payments so closely that payments and vouchers are being continually held up in order to conform to special rulings that may have been made some time in the last hundred years by the Treasury Department officials or by the Comptroller. The result is that the delay in the payment of those bills increases the cost of your work. For instance, I think there have been four contracts let for steam shovels, and, if I am not mistaken, I think you will find that every time you have let a contract for steam shovels you have had to pay a higher price than you did before.

Now, why was that? Because the contractor had so much trouble in conforming to the regulations and getting his money, and his payments were delayed so long, that in the next bid he made he had to add something to the price to cover that.

Of course I realize that you can not do Government business the same way that you can private business. But on railroad work, or in a business office, the system is reversed. It is the system, as we call it, of "audit before payment." In a corporation office all that the disbursing officer has to bother him is to either have the money or have the voucher properly signed. It does not make any difference to him whether the board of directors authorized that payment or not; if the managing officer of the company has properly signed that voucher, and the head of his department has approved it for payment before the money is paid out, all he has to do is to show that voucher or that money, and the whole process is reversed.

It is that thing that has gradually brought my mind to the idea that eventually you will have to let that work in one big contract. If you do that, the only thing you are concerned in is the certificate of the engineers that the work has been performed. One voucher covers it all. One voucher would cover all a contractor would do for a month or six months or a year, dependent upon the periods that the contract specified as payment periods. That contractor could pay out that money in a way that would expedite the work and not in a way that would retard it, and could relieve you of all this difficulty; and the probabilities are that while the contract price might be apparently more than what you could do it for under favorable circumstances for a short time, taking the whole thing together the contract price would permit the contractor to make his profit and still do his work for less money than it will cost you under the present method.

THE PROPER ORGANIZATION FOR THE CONDUCT OF THE WORK.

SENATOR KITTREDGE.—What kind of an organization do you recommend to conduct the work until the contract is let, at least?

MR. WALLACE.—Pending the letting of the contract—that is, if the work is to be continued by hired labor—the more you can condense that organization the better. My idea always has been that you can not obtain efficient executive action from any body of seven men. To get executive action you must have concentrated authority, and you must have authority and responsibility properly balanced.

If you are tied to the form of a commission and do not want to change from that, the most efficient way is, of course, an executive committee of three men. But the man who is in charge of the construction on the Isthmus, whether you call him chief engineer or whether you call him director of works, should be the head of that commission. The next man to him should be the governor of the Zone. The third man should be charged with the procuring of the supplies in the United States and the procuring of the men here, their shipment, and so on. But if there is any subordination at all, he should be subordinate to the man that has the supreme charge of the work on the Isthmus as chief engineer or director-general, or whatever you choose to call him; and that man should have as free, absolute power as you can give him.

The way matters are arranged there now, the Commission, which is the power immediately above him and which directs him, naturally knows less than he does. The chairman of that Commission naturally knows less than the Commission. Mr. Cromwell knows less than the chairman. The Secretary of War knows less than Mr. Cromwell. The President of the United States (who, under the Spooner Act, is charged with the entire responsibility) knows less than the Secretary. In other words, you have a chain of five masters over that man that you are holding responsible for the execution of that work down there, who is on the ground, and who is the man that has to give you the results.

SENATOR MORGAN.—In regard to the executive committee of three persons, is it necessary for the efficiency of such a committee that they should reside in the Zone and make that their place of residence as distinguished from Washington?

MR. WALLACE.—The headquarters of that work should be on the Isthmus, but I do not think it is fair to the man in charge of that work there to require him, either by law or order, to always continuously remain there. I think he ought to be free, if it is necessary for him to-morrow morning to get on a steamship to come to the United States for some official matter that he thinks ought to be attended to here, to have the privilege of coming without getting authority to come. The farther you can get that work away from Washington, and the harder you can make the line of communication to Washington, the better you will have that work conducted.

SENATOR KITTREDGE.—What do you suggest regarding the salaries that should be paid the Commissioners and their employees in canal construction?

MR. WALLACE.—As far as the chief engineer is concerned, Mr. Stevens or anybody else, I do not care who holds that office, there is no amount of money that you can pay him that is too large—that is, the way that work is run now.

SENATOR MORGAN.—How about the other man—the man that has to pay the money?

MR. WALLACE.—Well, as a taxpayer, I am willing to contribute my share of Mr. Stevens's salary if you make it $100,000 a year.

SENATOR MORGAN.—But you were willing to do it for $25,000?

MR. WALLACE.—No; my salary and that of Mr. Stevens were practically the same. I was furnished a house in Panama—that is, I got a house that was furnished—and the Commission gave me a carriage and a coachman and the keep of three horses, and the house was provided with one servant who was the custodian of the house, and they considered that equivalent to $30,000 a year.

SENATOR MORGAN.—You would be willing to raise his salary to $35,000 a year, including the furnishing of the house, the service, and the carriage, etc.?

MR. WALLACE.—Yes. When I was not willing to stay at twenty-five thousand, I think that is a sufficient answer that I do not think it is enough. (Laughter.)

SENATOR KITTREDGE.—What about the salaries of the other Commissioners?

MR. WALLACE.—If the other Commissioners reside in Washington and do not have any more authority or responsibility than they have now, I think they are well paid. If they should devote all their time to that work, and were charged with the responsibility, I should say that twelve or fifteen thousand dollars a year would be more reasonable compensation for them. If they reside on the Isthmus, I should say that the governor's salary is about right the way it is now. It should be somewhere between fifteen and eighteen or twenty thousand dollars a year—that is, if he is charged with the governorship of the Zone and the responsibility of a member of the executive committee and also acts as minister and looks after the state matters with the Government of Panama.

SENATOR MORGAN.—If there were six members of this committee at this table now, Mr. Stevens would get as much salary as all of those six members of the committee, would he not?

MR. WALLACE.—I presume so, and I presume he earns it. (Laughter.)

SENATOR MORGAN.—The Secretary of War is a man who has done and has been compelled to do an immense amount of traveling and an immense amount of work in connection with this canal, in addition to other duties.

MR. WALLACE.—Yes, sir; he does not get enough money. But because he can not receive the compensation he deserves by law is no reason why you should trim the salary of a poor man like Mr. Stevens or anyone else that has got to live down on that Isthmus and do the work—who can readily obtain satisfactory employment in this country.

SENATOR MORGAN.—How would it be about Mr. Shonts, who is not an engineer at all, as you testified?

MR. WALLACE.—Well, if Mr. Shonts is going to live in the States, and is not going to the Isthmus at all, and is going to confine himself to the purchase of supplies and things of that kind, I think he gets too much.

SENATOR MORGAN.—What I want to get at is this, whether or not living and doing work on the Isthmus is under such conditions of danger from disease and such conditions in other respects as that the salary ought to be largely increased, if the man resides there?

MR. WALLACE.—Yes, sir; I should say that you ought to make a difference of probably 50% as compared with the compensation in the United States.

SENATOR MORGAN.—Is that difference made between the pay of laborers, for instance, in the United States generally, or the pay of laborers on the canal?

MR. WALLACE.—You can not compare those two things, because the laborers on the canal are not laborers that you take in the United States. I do not think that you could take labor from the United States and get it to go there for less than 50% more than you pay it here.

SENATOR MORGAN.—Would it not be 50% better than the labor you employ there if you could get it?

MR. WALLACE.—Not after it had been there a year.

SENATOR MORGAN.—And after that it would decline, on account of the climate?

MR. WALLACE.—Yes, sir. The way I sized up that labor was about as follows: I found the southern negro, south of the Ohio River, when I was engaged in railroad work, about half as efficient as the best form of track labor that we had in northern Illinois and Iowa—that is, our Swedes and Germans and labor of that class. But when I got to the Isthmus I found that the negro labor there was worth just about half what our negro labor was in Mississippi and Louisiana.

SENATOR MORGAN.—Then the negro labor in the Isthmus is of one-fourth the value of high-class railroad white labor throughout the Northern States?

MR. WALLACE.—Yes, sir. Now, I think that possibly can be partly corrected, because the labor on the canal has been brought in from the islands where these men are not regularly employed, and they only have to work now and then in order to make a bare living. After that labor is disciplined and trained by proper foremen, I have not any doubt that it will be possible to very materially increase its efficiency. It may be possible to get it up to somewhere near that of the Louisiana negro; but that is a question.

SENATOR KITTREDGE.—Does the statement you make, applicable to the wages of the laboring man, extend to the classes between the laboring man and the officials?

MR. WALLACE.—To almost all employees, mechanics, etc.; but the thing that will regulate that mechanical laborer is this: You can make a rule of this kind apply to your civil engineers and your clerical men and men of that class; but when it gets down to your mechanics, like your steam-shovel men, your locomotive engineers, your machinists and blacksmiths and boiler makers and molders and carpenters and that class of men, you have got to change their wages from time to time to meet the conditions in the United States and the law of supply and demand. I first tried to get skilled labor on the basis of an increase of 25% over the United States prices, and I was not able to get a solitary steam-shovel man to go down there on that basis; and we finally made an adjustment on a basis of about, I should judge, 40% in advance of the United States wages.

REPORT OF THE BOARD OF CONSULTING ENGINEERS FOR THE PANAMA CANAL.

II.

The Minority Report, Recommending a Lock Canal.*

The undersigned, a minority of the Board, concurring with much of the preceding report, dissent from the preference expressed for a sea-level canal. We present for comparison with the 60-ft. level project preferred by the Board a project with summit level at elevation 85 maintained by a dam and duplicate flights of three locks at Gatun. This is recommended for adoption, General Abbot preferring a lower dam with duplicate flights of two locks at Gatun, supplemented by a dam and duplicate single locks at Bohio, raising the summit level to elevation 85, as before.

(A) THE COLON ENTRANCE.

Commencing the description at the Atlantic end, the plan of the Board for a breakwater in Limon Bay is, with only a slight change, adopted for purposes of estimate. The change consists in swinging the long westerly line out from the shore at Mindi Point far enough to permit the channel (500 ft. wide and 41 ft. deep at mean tide) to be made through the easily dredged earth outside the point, instead of inside the point, where there would be much expensive rock excavation. The breakwater and channel as modified will be extended to the head of the bay. It seems possible that the breakwater may be dispensed with wholly, or in part, and the channel widened to 1,000 ft. or more, to the advantage of navigation and with a reduction of cost.

(B) THE GATUN DAM.

The controlling feature of the project with summit level at elevation 85 is the earth dam across the Chagres at Gatun. The object of this dam is to form a great reservoir, or inland lake, in which the floods of the Chagres will be received and from which the surplus water will be discharged through sluices and the height of water in the reservoir regulated. Lake Gatun will be about 110 square miles in area and will form the summit level of the canal. The lake will also serve to impound water for lockage and other purposes during the dry season and to give free, open navigation in a broad waterway all the way from Gatun to Obispo.

The borings made prior to September, 1905, at and near Gatun showed nearly everywhere an admixture of sand with clay and impervious material, with a maximum depth of rock of 204 ft. below sea level. Many of the borings, even those at considerable depths, encountered shells, wood and vegetable matter, all tending to show that the material had been deposited in currents too sluggish to transport gravel and other coarse material.

The borings were "water jet" or "wash drill" borings, made by first driving, when necessary, an iron pipe (known as a casing) having an inside diameter of 2 or 2½ ins., and then inserting a smaller pipe, through which a jet of water was forced, washing the material in the larger pipe through the annular space between the two pipes to the surface of the ground. It was characteristic of these borings, and also significant, that in many cases it was not necessary to drive any casing; or, if one was driven, it was not necessary to drive it to the full depth, as the material contained enough clay to sustain the sides of the hole without the casing.

Of 27 borings made before September with reference to the location of a dam at or near Gatun, no casing was used in 13 holes; in three other holes the length of casing did not exceed 20 ft., while in the remainder the depth of casing ranged from 28 to 101 ft., but in no instance was the casing driven much more than halfway down to the bottom of the hole.

The depth to rock was shown to be so great, both at Bohio and at Gatun, that it would be costly and difficult in either case, if not impracticable, to excavate to the rock or to provide any efficient cut-off or stop-water extending from the surface of the ground to the rock; and if a dam were to be built without such cut-off the borings showed clearly that there would be less seepage beneath a dam built at Gatun than at Bohio.

The location of all borings is shown on the map of the Gatun dam site, Fig. 4, and the borings on a line across the valley at the dam site are shown in Fig 6.

It will be noticed on Fig. 6 that there are two deep depressions or gorges in the rock, which have been filled with alluvial material. The deepest boring penetrated this material 258 ft. before striking rock. The lower 50 to 60 ft. of the material in the deepest gorge was found to be for the most part porous sand and gravel, which was undoubtedly deposited at a time when the currents through the gorge were swifter than existed when the upper 200 ft. of the alluvial material was deposited. In the upper 200 ft. some of the later borings show fine sand, while other borings near by show clay at the same depths, indicating, as do previous borings, that the upper 200 ft. is practically impervious material. There was an outflow from several of the borings which penetrated the gravelly material in the bottom of the deep gorge, although the tops of the casings were above the surface of the river. This showed conclusively that there was no near connection with the bed of the river; in other words, that the material covering the sand and gravel was impervious for a long distance.

We believe as a result of the borings which have been made that if a large earth dam were to be built at Gatun, as indicated upon the drawings, there would be no appreciable seepage under the dam, owing to the practically impervious nature of the material on which it would rest and to the fact that the more pervious material found at the bottom of one of the gorges in the lower 50 ft. is covered by a blanket of practically impervious material 200 ft. thick.

The borings on the high ground, at the site of the locks, the regulating works, and elsewhere, showed generally soft clay to a depth of 20 to 30 ft. below the surface, where indurated clay—a soft but compact rock—was found.

In making the design of an earth dam at Gatun, it was thought best to provide a dam which could not be destroyed by any of the forces of nature, and which could only be destroyed by making excavations which would require a large force working for a long time.

The cross-section of the dam has been given the unprecedentedly large dimensions shown on Fig. 7. Its top is 50 ft. above the water level in the lake and 100 ft. wide; at the water level the distance through the dam is 374 ft., and at sea level the corresponding distance is 2,625 ft., or one-half mile.

It is intended that the downstream toe of the dam for about 200 ft. shall be composed of rock obtained from excavation in the canal prism, so that if there should be any seepage of water through the dam there will be material at the toe which cannot be washed away. The lower part of the dam, up to elevation 50, or even to elevation 80, is to be made from material dredged from the canal between the Gatun locks and Limon Bay, pumped by a suction dredge into the dam, the process being similar to the sluicing process employed in the construction of some important dams in the western part of the United States. By this process it is feasible when using a material like the alluvial material at Gatun, which contains both coarse and fine material, to separate the two and to deposit the coarser material toward the downstream slopes, forcing the finer material to the extent desired into the upstream portion of the dam. An embankment built in this way will be water-tight.

For the upstream slope, rock obtained from canal excavations will be dumped as riprap, care being taken to provide an ample thickness at and near the level where the dam will be exposed to wave action.

The portion of the dam above elevation 80 will be built of impervious material to a few feet above the water level, and at higher levels may be made of either earth or rock, as most convenient. It is expected that for the upper part of the dam, spoil from the Culebra cut will be used.

While earth dams are in common use, and in many cases support greater heads of water than would exist at the proposed Gatun dam, it will still be argued by many that in a great work like the Panama Canal nothing should be trusted but the most massive masonry dam on a solid rock foundation. At Gatun the rock lies at so great a depth that a masonry dam thus founded is impracticable, and without such foundation a masonry dam would be most unsuitable. It seems desirable, therefore, to enter to some extent into the discussion of the stability of the proposed earth dam.

STABILITY OF AN EARTH DAM.—It is obvious that if a dam of this kind is to fail, some part of its length must be pushed away bodily, or the earth of which it is composed must be carried away by currents of water. There are no other natural forces which can materially affect the stability of the dam

The horizontal pressure of the water in the lake per linear foot of dam is less than one sixty-third of the weight of the dam per linear foot, a pressure so small that it is obvious that it cannot move the whole mass, and there is left, therefore, as the only way in which a dam of this kind may fail, the carrying away of its parts by a current of water.

The currents of water requiring consideration are those resulting from the action of the waves, from the rainfall, or from seepage through the dam.

The feasibility of protecting the face of the dam from the action of waves will hardly be questioned. The effect of the rainfall can easily be provided for, particularly on the main downstream slope, which falls but 1 ft. in 25.

It is impossible for water to flow over the top of a dam that is raised 50 ft. above the water level, and if the dam and the underlying material were strictly impervious there would be no water from the lake passing through it. On the other hand, if the material in or under the dam is somewhat pervious, there will be some water passing through which will appear at the surface, either immediately below the dam or toward the lower portion of the downstream slope.

The amount of water which will pass through [a somewhat pervious material in or under a dam depends] upon the relation between the total head and the distance through the dam, and not, as is sometimes assumed, upon the total head against the dam.

If two dams are built under similar conditions, except that one has a thickness five times as great as the other, then there will be at the dam having the greater thickness only one-fifth as much seepage as at the other; that is to say, other things being equal, the seepage through a dam will be substantially in proportion to the depth of water against the dam, divided by the distance through the dam, giving what may be called the hydraulic gradient or slope of the line of saturation, which in this case does not exceed 4%.

There have been many experiments on the vertical and horizontal filtration of water through various kinds of materials and with various hydraulic gradients. Some of these were made at the Lawrence Experiment Station of the Massachusetts Board of Health and others were made at the Wachusett reservoir of the Metropolitan Water-Works, in Massachusetts, in connection with the construction of a dam similar to that proposed at Gatun. These experiments were made with materials of uniform character, through which more water would filter than through materials containing fine and coarse particles of the same average degree of coarseness, such as those found at the site of the Gatun dam, and they furnish results which confirm the statement already made that there would be no appreciable seepage under this dam.

If, however, a condition which *does not exist* be assumed, and all of the alluvial material beneath the embankment of the dam were considered to be a clean and reasonably uniform sand of medium size, the total amount of filtration would then be for the whole length of the dam only about 10 cu. ft. per second. Even this amount, which is much larger than would actually exist, is insignificant, and is less than one-half of one per cent. of the water supply available in the driest season.

Few engineers who have been connected with the filtration of city water supplies would hesitate to provide works which would permit the amount of water above stated to rise to the surface without carrying with it any of the earth, because they have a much more difficult problem in connection with the downward filtration of water, where the works must be so built that the sand will not be carried down with the water.

The method followed in water filtration is to place coarse stones at the bottom of the filter and to cover these stones with finer and finer stones, and then with coarse sand, in order to retain the finer sand used for filtration. It is a simple operation to build the reverse of such a filter, which will permit the water to rise from the ground without carrying the earth with it.

It is not expected that there will be enough seepage through the Gatun dam to require any special treatment, but if there should be it could readily be taken care of by the method which has already been used with success in connection with a dam built of sand on a sand and mud foundation at Jeypore, India.

Such a dam as is here proposed if not absolutely earthquake proof is probably more nearly so than any other type of dam.

A comparison between the section of the Gatun dam and that of a few existing earth dams is shown on Fig. 7. The San Leandro dam of the Contra Costa Water Co., 120 ft. high, which supplies water to Oakland, Cal., is the highest earth dam in the world, and it was constructed in part by sluicing. The Pilarcitos dam, 95 ft. high, built in 1866 by the Spring Valley Water Co., which supplies water to San Francisco, is also one of the larger dams, although there are several others of about the same size, which have been successful.

The Jeypore dam is introduced on the diagram because it was built of sand on a foundation of sand, mud and soil, and at a place where the material is very pervious, so that considerable water filters under and through the dam. It has, however, proved to be stable under these conditions.

The United States Reclamation Service has recently planned an earth dam to sustain a head of 100 ft. with a width at the water line less than one-fourth that proposed for the Gatun dam and with a proportionately narrow base.

It will be noted that these dams have a small section in proportion to the depth of water behind them when compared with the Gatun dam.

Earth dams are in such common use, are so generally indorsed by engineers, many of whom prefer them to other forms, that this extended discussion has been given only because the proposed use of earth dams has been unduly criticised in the report of the Board.

The nearest precedent in general design for the Gatun dam is the north dike of the Wachusett reservoir of the Metropolitan Water-Works, of Massachusetts, which is two miles long and at the deepest place will have 65 ft. of water against it. The highest portion of this dike was built on exactly the plan proposed for the Gatun dam, namely, the fine material of which the dike is com-

*The drawings and maps accompanying this report were published in our last week's issue.

posed was deposited on the fine underlying material without the use of either masonry or sheet piling to prevent the filtration of water. Under portions of this dike the depth to the rock is as great as at the Gatun dam.

PLAN OF THE DAM.—Fig. 4 shows a plan of the dam. Its total length from the locks to the westerly end is 7,700 ft. About midway in the length of the dam there is rising ground in which it is proposed to excavate, as already indicated, a diversion channel through which the Chagres will flow during the construction of the earth dam.

The regulating works, to be subsequently described, will be built mainly of concrete and will be located in part in the diversion channel and on each side of it. On each side of the rising ground referred to, and extending from it westerly to the high ground and easterly to the locks back of Gatun, there will be great earth embankments of the cross section already described, which will together contain 21,200,000 cu. yds. of material. The westerly embankment will cross a French diversion channel. The easterly embankment will cross the French canal and the Chagres.

It will be feasible to begin at once the construction of one of the earth embankments, permitting the water to flow through the channel or channels at the side of the other embankment. It will also be feasible to begin at once the construction of the diversion channel, utilizing the material excavated in the embankments of the dam.

In the construction of the dam it is proposed to remove all trees, stumps, and roots from its site and to excavate the surface material to such an extent that the impervious material of the embankment will come in direct contact with the impervious clayey material which is found nearly everywhere in this region; also to do any other work required to cut off the flow through any pervious material which further investigations may disclose. For such work an allowance of $400,000 for all dams has been made in the estimate of cost.

The diversion channel is to have a minimum width of 150 ft. and is to be excavated to sea level, or somewhat below it; although the lower part of the channel will be through indurated clay, it is proposed to place in it concrete where required for the protection of the channel or for the regulating works up to sea level, and to build in the channel to an elevation about 4 ft. above sea level the foundations of certain piers and walls, which will remain for a time at this elevation, so that they will form only a slight obstruction to the discharge of flood waters.

After the earthwork of the dam reaches a sufficient height to be beyond all danger of overflow, the piers and walls, which will be above water at low stages of the river, and which will have in them grooves for stop planks, will be built to higher elevations to furnish a ready means of turning the river through half of the diversion channel while the other half is pumped dry to permit the placing of the concrete of the regulating works, and by turning the river alternately from one side to the other the regulating works may be built without special difficulty.

REGULATING WORKS.—The general design of the regulating works is shown in Fig. 5. The central 150 ft. of their length, which will be built up from the bottom of the diversion channel, is to be a solid mass of concrete, having its crest at elevation 60. The crest is to be made wide with the down-stream slope two horizontal to one vertical, making an unusually strong section.

On the top of the crest, piers 8 ft. in thickness, grooved for Stoney sluice gates, are to be built 38 ft. from c. to c., having clear openings of 30 ft. These gates, as proposed, are almost exact counterparts of the gates provided for controlling the flow from the lower end of the Chicago Drainage Canal, but the sills are to be placed 16 ft. below the normal water level, instead of 15 ft., as at the Chicago Drainage Canal.

The regulating works are capable of discharging 140,000 cu. ft. per second when the water in the lake is not more than one foot above the normal level.

With the uncontrolled spillway 2,000 ft. long, recommended by the Isthmian Canal Commission of 1899-1901 in connection with the Bohio dam, it was estimated that the water in the lake might be raised 5 ft. above its normal level by a maximum flood.

With the regulating works proposed in connection with the Gatun dam it is estimated that the surface of the lake will never be raised by a maximum flood more than 2 ft. above the normal level, and with ordinary floods it would be feasible by beginning the discharge before the flood waters reached the lake to keep the surface from rising to any appreciable extent.

REDUCTION IN COST IN COMPARISON WITH THE BOHIO DAM PROJECT OF 1901.—The great quantity of material to be placed in the Gatun dam may cause it to be inferred that a structure at this place adds to the cost of the canal; but it should be borne in mind that the adoption of this site eliminates large expenditures for the canal and diversion channels between Gatun and Bohio. A comparison shows that there is a saving of $11,804,621 in the estimated cost of works by the change in the location of the dam, made up as follows:

WORKS OMITTED.	
Bohio dam	$6,369,640
Gigante spillway	1,200,419
Canal between Gatun and Bohio	7,643,067
Pena Blanca outlet	2,448,076
Chagres diversion	1,929,982
Gatun diversion	100,000
	$19,700,184
Add 20% for contingencies, etc.	3,940,037
Total for works omitted	$23,640,221
ADDITIONAL WORKS REQUIRED.	
Gatun dam	$7,788,000
Panama Railroad diversion from Mindi to Bohio	2,000,000
	$9,788,000
Add 20% for contingencies, etc.	1,957,600
Total for additional works required	$11,745,600
Amount saved by change in location of dam	$11,894,621

The estimates of the cost of the works omitted were made by the Isthmian Canal Commission of 1899-1901.

The adoption of Gatun as a site for a dam not only provides for reduced cost and a better lock site, but, as compared with Bohio, it offers several important advantages. The first of these is a large addition to the drainage area tributary to the summit level and to the amount of water available for canal uses, which is of special value during the dry season; the second is the great increase in the reservoir area, Lake Gatun having almost three times the area of the lake formed by a dam at Bohio; this permits storing water for the dry season and the reception of floods with a maximum variation of lake level of only about one-half of that taken by the first Isthmian Canal Commission for Lake Bohio. A third advantage which will be described more fully farther on is the extension of lake navigation 9½ miles toward the Atlantic from Bohio; a fourth is that the Chagres and all its important tributaries will be received into the lake at points so distant from the canal route that no deposit of suspended material will occur along it, and a fifth is that the water discharged from the lake will enter the Chagres at the point where it finally diverges from the canal so that no diversion channels or heavy protecting embankments will be required along the canal line.

(C) WATER SUPPLY OF THE CANAL.—The volume which would flow into Lake Gatun in the dry season is about two-thirds greater than that into a lake formed by a dam at Bohio, and the minimum contribution to Lake Gatun, judging from the record of measurements of flow covering a period of 15 years, is 1,250 ft. per second during the driest three months. In order to provide for still drier periods it has been thought advisable to adopt 80% of this volume, equal to 1,000 cu. ft. per second, as an entirely safe quantity.

The lake can be safely raised toward the end of the wet season 1 ft. above the normal level, and provision has been made in the design of the canal for drawing the lake 3 ft. below the normal level, so that the contents of the upper 4 ft. of the lake, equal to 12,270,000,000 cu. ft., will be available for water supply purposes during the dry season.

This quantity will provide a steady flow of 1,577 cu. ft. per second for 90 days, making the total quantity of water, after adding the inflow, 2,577 cu. ft. per second.

Not all of this water, however, is available, as it is necessary to deduct losses by evaporation and leakage, and it is also convenient to use some of the water to furnish power for operating the gates, for lighting, and for other purposes.

The quantities required for these purposes are as follows:

	Cu. ft. per second.
Evaporation	710
Leakage at gates	240
Infiltration, waste at locks, etc.	77
Lighting, power, etc.	200
Total	1,227

The net quantity of water available for lockage is, therefore, the difference between 2,577 and 1,227, equal to 1,350 cu. ft. per second.

To determine the number of lockages which this quantity of water will provide for, the following provisions and assumptions have been made:

Intermediate gates are to be provided for the locks at Pedro Miguel and Sosa, so as to give a chamber length of 600 ft., and it is assumed that the intermediate gates will be used for eight-tenths of the lockages. At the Gatun locks intermediate gates would not furnish the same advantages for saving water, as there are three locks in a flight, and they are therefore omitted.

It is further assumed that all ships passing in one direction will use one set of locks, and all ships passing in the other direction another set. On this assumption, the same quantity of water is used whether a ship passes through a single lock or through two or three locks in a flight.

The lift to the normal summit level at Pedro Miguel is 30 ft. and at Gatun 28½ ft. per lock. The quantity of water required per lockage at Pedro Miguel, on the assumption that intermediate gates will be used eight-tenths of the time, is 22.13 cu. ft. per second, and the quantity per lockage at Gatun 29.77 cu. ft. per second, making a total of 51.90 cu. ft. per second.

The net available quantity of water is, as already stated, 1,350 cu. ft. per second, and will therefore provide for 26 lockages per day at each lock during the driest three months.

In order to provide for more lockages per day it will only be necessary to store more of the freshet water. The Alhajuela dam, raised to the height proposed by the Comité Technique, would store enough water to provide for fully 27 additional lockages per day.

In order to determine the amount of tonnage provided for by the 26 lockages per day, for which the water supply is sufficient without the Alhajuela dam, it is necessary to take into account the amount of tonnage which will pass through the canal per lockage, and in this connection it should be noted that the full-sized locks will pass two ordinary ships at a time.

The size of the ships passing through the Suez Canal has been increasing from year to year; they averaged 3,163 tons per ship in 1904 and 2,398 tons per ship ten years earlier. The rules for measuring tonnage at this canal, however, gives a measurement in excess of that given by Lloyd's net register of about one-sixth.

It seems probable that when the traffic at the Isthmus requires 26 lockages per day, in view of the growth in the size of ships and of the fact that two ships of ordinary size can pass through a lock at the same time, the amount of tonnage per lockage will be as much as 5,000.

The annual tonnage provided for by the water supply, both without and with the Alhajuela dam and on a basis of 3,000, 4,000 and 5,000 tons per lockage, is as follows:

Tons per lockage.	Annual tonnage without Alhajuela dam.	Annual tonnage with Alhajuela dam.
3,000	28,470,000	58,035,000
4,000	37,960,000	77,380,000
5,000	47,450,000	96,725,000

Should it be found necessary in the future to provide for the passage of a still larger tonnage, the Chagres and its tributaries will furnish additional water, which may be stored and subsequently utilized.

(D) THE SUMMIT LEVEL.

As already stated, the summit level will be reached from the level of the Atlantic by means of duplicate flights of three locks at Gatun. The flights being in duplicate give security against serious delays to ships in case one flight is out of use, as it must be occasionally to make the repairs and renewals necessary for efficient work. The facility afforded for repairs by duplicate locks meets any objection that there will be no period at the Panama Canal for repairing gates and other mechanism.

The total length of the lake will be 30 miles, of which 23 miles will be navigated by ships crossing the Isthmus. Its depth will be about 75 ft. in the immediate vicinity of the dam, this being maintained with little reduction to Bohio and thence reducing gradually toward Obispo, where the depth of 45 ft. will be obtained with but little excavation, the bed of the river being about 45 ft. below the surface of the future lake.

For 15.69 miles above the Gatun locks the deep portion of the lake will have generally a width exceeding half a mile, and only a small amount of excavation will be required to provide a navigable channel nowhere less than 1,000 ft. wide at the bottom and 45 ft. deep. Farther up the lake, as the amount of excavation required to obtain a depth of 45 ft. increases, the minimum width of the channel will be decreased, first to 800 ft. for a distance of 3.86 miles from San Pablo to Juan Grande, then to 500 ft. for 3.73 miles to Obispo, and to 300 ft. for 1.55 miles from Obispo to Las Cascades, where the channel will be further narrowed to 200 ft. through the heaviest portion of the great central mass known as Culebra.

The broad waterway from Gatun to Culebra really furnishes lake navigation and closely resembles the great navigable channels in many harbors and those through the succession of small connected lakes between Lakes Superior and Huron, called the St. Mary's River, where the dredged channels in the shallower waters are 300 to 600 ft. or more in width and are traversed by a tonnage of more than 3,300,000 net registered tons per month.

Where changes of direction occur, the outer channel lines of adjacent courses are to be carried to an intersection, although very little excavation is required to accomplish this; the point of the inner angle will be dredged off so that a curve of 8,000 ft. or more radius can be laid down wholly within the channel limits.

For a distance of 4.7 miles through the deep portion of the Culebra cut the channel is to have a bottom width of 200 ft. and to have nearly vertical sides below the water line, and then will become 300 ft. wide for 1.88 miles to the Pedro Miguel locks, where the summit level will end. In the vicinity of the locks a low earth embankment without a spillway will be required on the west side. The duplicate locks at Pedro Miguel will have one lift of 31 ft.

(E) LAKE SOSA.

Passing the locks, the channel will be 500 ft. wide for 1.64 miles, then increasing to 1,000 ft. or more for the further distance of 3.38 miles to the Sosa locks on the shore of Panama Bay. This broad navigation will be in an artificial lake created by three dams to be subsequently described. There are to be duplicate flights of locks on the west side of Sosa Hill near La Boca, with two lifts of about 31 ft. each, from ordinary low tide to the level of Lake Sosa.

When the Board began its work, sufficient information for determining the feasibility of building dams to create a lake at the Pacific end of the canal was not available, and the Isthmian Canal Commission was requested to have additional surveys and borings made at dam and lock sites. As a result of investigations made in compliance with this request it was found to be entirely feasible to build three dams which would retain water to a height of 55 ft. above mean tide, and create a lake having an area of about eight square miles, extending along the line of the canal to Pedro Miguel. It was also found that on the westerly side of Sosa Hill, near the La Boca pier, there is a suitable site for duplicate flights of two locks each.

The principal dam is the one at La Boca, which extends from the locks at Sosa Hill across the mouth of the Rio Grande to San Juan Hill. The other dams extend from Sosa Hill to Ancon Hill, and from Ancon Hill in the direction of Corozal to high land just across the Panama Railroad.

At the La Boca dam the greatest depth to rock shown by the borings is 64 ft. below "spring low tide" and the material overlying the rock is impervious, consisting of mud and clay. At the other dams the borings showed rock but a short distance below the surface. These dams have very liberal dimensions, following in this respect .... precedent established in the design of the Gatun dam.

The question having been raised as to the stability of the material at the site of the La Boca dam, the upstream side as well as the downstream side of the cross section of this dam was given a very wide base so as to insure the compression of the mud and clay rather than its displacement. During construction special provision will have to be made for shutting off the tidal flow in the Rio Grande, for which a sum has been allowed in the estimates.

In order to provide for the discharge of the Rio Grande and other rivers entering the lake during the construction of the earth dams, a diversion channel about 50 ft. wide is to be cut through the slope of Sosa Hill, near the end of the Ancon-Sosa dam, and sluices or regulating works, similar to those proposed for the Gatun dam but of much less extent, are to be subsequently built in this channel.

The advantages of the terminal lake are a reduction of about $8,000,000 in the cost of the canal and the greatly improved navigation, due to introducing 5.48 miles of channels not less than 500 and 1,000 ft. wide and 45 ft. deep.

(F) CHANNEL IN PANAMA BAY.

From the Sosa lock to the seven-fathom curve in Panama Bay, a distance of four miles, the channel is to be 300 ft. wide at the bottom and 45 ft. deep below mean tide. While this width and depth might be made greater with advantage to navigation, they are the dimensions adopted by the Board for the sea-level project with which the project here advocated is to be compared. Moreover, since it must be expected that considerable dredging will be required to maintain this channel, there is no doubt that it will be gradually enlarged by the dredges provided for maintenance.

Excepting near the locks the location of this channel is the same as that of the French company. It therefore renders available the excavation already made there by that company and, more recently, by the United States. With only a small amount of excavation access can be maintained for ships to the La Boca pier, built a few years ago at a cost of about $1,000,000. This pier will be of great service as a landing place during the construction of the canal, and very useful for a coaling station subsequently. The closing of the mouth of the Rio Grande by a dam, as previously described, will stop the existing tidal currents into and out of the estuary and entirely remove the most serious objection made by the Board to the French location.

COMPARISON WITH THE BOARD'S SEA-LEVEL CANAL PROJECT.

The sea-level canal is fully described in the report of the Board. The most striking points of differences affecting navigation are with respect to number and dimensions of locks and dimensions of the waterway.

SIZE OF LOCKS.—The Spooner Act provides that the canal "shall be of sufficient capacity and depth as shall afford convenient passage for vessels of the largest tonnage and greatest draft now in use, and such as may be reasonably anticipated." Since the passage of this act the Cunard Co. has projected two ships for the North Atlantic route of very much larger dimensions than any built heretofore. The new ships are to be 800 ft. long, 88 ft. beam, and to have a draft of 36 ft. They are specially designed for fast service between England and New York. They are subsidized by the British Government, are to be at its service in time of war, and are not likely in any conceivable circumstances to traverse the Panama Canal. But the language of the act makes it necessary to plan the canal for these ships and for larger ones if they "may be reasonably anticipated." What are the ship dimensions which may be reasonably anticipated is a question about which great difference of opinion may exist.

The accompanying table shows the number of commercial and war vessels now in use, of medium size or larger, classified with respect to beam:

BEAM OF LARGE OCEAN STEAMERS.

Beam.	Commercial ships in use.	War ships in use or projected.	Total.
40 to 45 ft.	2,101	201	2,302
45 to 50 ft.	1,993	139	2,132
50 to 55 ft.	692	110	802
55 to 60 ft.	177	83	260
60 to 65 ft.	53	44	97
65 to 70 ft.	26	123	149
70 to 75 ft.	6	85	91
75 to 80 ft.	3	81	84
80 to 85 ft.	..	8	8
Total	5,051	874	5,925

This table shows most clearly how insignificant in number are the commercial ships exceeding 70 or even 60 ft. beam. The broadest commercial ships in use are less than 76 ft. beam, and if we exclude the projected Cunarders, which of all seagoing ships are the least likely to pass through the Panama Canal, a length of 700 ft. and a beam of 76 ft. may be taken as the dimensions of the greatest commercial ships now in use or building which are at all likely to pass through the canal.

The table also shows eight war ships projected of more than 80 ft. beam. The beam of these is definitely known only for the new Japanese battle ships of the "Satsuma" class, which are to be 83 ft. 6 ins.

The steady advance in ship dimensions since the introduction of steamships is well known, and while at almost any period there have been a few ships too large for the current traffic and existing harbor facilities it can not be doubted that as traffic increases and harbor facilities are improved ships of larger dimensions will come into profitable use. While a limit may be near at hand, as some well-informed experts believe, it seems clear that the limit has not been reached, although in the class of cargo steamers by which the greater part of the seaborne commerce of the world is served there has been little or no general advance for several years. From such somewhat conflicting data a judgment must be formed as to what further increase of ship dimensions "may be reasonably anticipated." In forming such judgment it is believed that the period for which such reasonable provision is to be made should also be a reasonable one; for example, probably no one would expect to provide in any commercial or military construction for needs at the end of the present century.

The Board adopted for lock dimensions a width of 100 ft. and usable length of 1,000 ft., which are sufficient for a ship of more than double the tonnage of the great ships recently placed on the North Pacific route, the "Dakota" and the "Minnesota" (which are so much larger than any other on the Pacific that they must be considered experimental), and are ample for a ship of about 40% greater tonnage than the projected Cunarders, which are much larger than any other ship built or projected for any route. We believe this allowance for reasonable anticipation excessive, and that locks 95 ft. wide, with a usable length of 900 ft., will fully meet the requirements of the act for both commercial and war ships, and recommend the adoption of these dimensions. They provide for ships nearly double the tonnage of the "Dakota" and "Minnesota," or 25% larger tonnage than the projected Cunarders. The width will permit the passage of a battle ship of 13 or 14 ft. greater beam than any ship now in use or building for the United States Navy.

If the locks are larger than necessary, they will not only cost more, but will require a larger water supply and will not be quite so convenient to operate. The gates must be larger, the locks can not be filled or emptied so quickly, and therefore a little longer time will be required to pass ships; in other words, if the locks are larger than necessary, they will not serve commerce as well as smaller ones.

We do not believe it is wise to attempt to meet the possible requirements of a distant future, which might be estimated erroneously and would burden the commerce of the present and near future with unfavorable conditions, but that it would be more judicious to build the canal with reasonable but not excessive allowances for further developments. If the locks should prove, after many years, to be too small, larger ones can be built when needed, and in the meantime the structures of more moderate size will have rendered better service to commerce.

WIDTH OF CHANNELS.—The second striking difference between the two projects affecting navigation is in respect to width of channel. Wherever, in recent times, natural waterways have been improved or artificial channels made for purposes of navigation the [illegible] work has been speedily followed by demands for [illegible] wider and straighter channels.

In the plan for the Panama Canal herein recommended, all of the route except the locks and a short [illegible] the deepest part of the Culebra cut will consist of channels 300 to 1,000 ft. or more in width. In the sea-level plan, on the other hand, such channels are provided only in Limon Bay and from the tidal lock to deep water minus in Panama Bay. About half the distance from Mindi to Miraflores would be in curves, and no provision of the channel in curves is provided for. Ships of the largest size could traverse the lock canal day and night without difficulty, but night navigation in the sea-level curves of the sea-level canal would be hazardous, except for smaller craft. In the accompanying table the two plans are contrasted with respect to channel [illegible]:

Bottom width of channel.	Lock canal with summit level at elevation 85. Length. Miles.	Per cent. of route.	Sea-level [illegible]. Length. Miles.	Per cent. of route.
1,000 ft.	19.08	38.4	0.00	0.0
800 ft.	3.86	7.8	0.00	0.0
500 ft.	12.29	24.7	4.87	9.9
350 ft.	0.00	0.0	0.77	1.6
300 ft.	7.21	14.5	3.05	6.2
200 ft.	4.70	9.4	19.47	39.6
150 ft.	0.00	0.0	20.39	41.5
Locks and approaches	2.58	5.2	0.59	1.2
Total	49.72	100.0	49.14	100.0

The lock canal will be less than 300 ft. wide for only one-seventh of its length and for more than two-thirds of its length will be 500 ft. or more wide; it will be nowhere less than 200 ft. wide. The sea-level canal for nearly half its length would be only 150 ft. wide, and for nearly five sixths of its length would not exceed 200 ft. Moreover, in the portion 200 ft. in width there are stretches where the lower part of the canal is in rock which does not reach the surface of the water, a condition particularly unfavorable to safe navigation.

The lock canal is not only greatly superior to the sea-level canal in regard to width, but is also decidedly superior in regard to depth. The sea-level canal is planned to be 40 ft. deep below the level of mean tide except in Limon Bay, where it would be 41 ft., and in Panama Bay, where it would be 45 ft. below mean tide.

At low tide the depth of water in the canal for some distance inland from Limon Bay would be a little less than 40 ft. The plans for the sea-level canal contemplate the direct admission of the water of silt-bearing rivers of moderate size into the canal, and, in some instances, into the portions of the canal having a rock bottom. Under such conditions it will be difficult and expensive to maintain the full depth of 40 ft. by dredging. In the lock canal, as planned, the sea-level section on the Atlantic side will have a depth of not less than 40 ft. of water throughout at any stage of the tide. In the summit level the depth will be 42 ft. or more at extreme low water in the driest season, and 45 ft. or more under usual conditions. From Pedro Miguel to Sosa the depth will be 45 ft. or more. The decided advantage to large ships of these increased depths will be recognized by all who are familiar with the difficulty of steering when there is but little water under the keel.

RELATIVE TIME FOR COMPLETION OF SEA-LEVEL AND 85-FT. PROJECTS.

The Board estimates that the sea-level canal can be built, with favoring circumstances, in twelve or thirteen years, this being the estimated time required to excavate the central mass usually called the Culebra cut, including all the excavation between Obispo and Pedro Miguel. This section is 8.08 miles long, and for the sea-level canal requires 110,000,000 cu. yds. of excavation, the heaviest mile requiring 22,000,000 cu. yds. and the heaviest 3,136 ft. (which is the length of the Gatun flight of three locks for the 85-ft. level canal), 14,000,000 cu. yds.

This estimate of time is based on an estimated output of 800 cu. yds. per day of ten hours for each steam shovel employed, the number of steam shovels to be increased to 100 as rapidly as they can be installed. Toward the end of the work the space would be restricted and the number of shovels would have to be reduced. It is recognized by the Board and by all others who have given attention to the subject that the real problem of excavation is to dispose of the excavated materials and to keep empty cars at the shovels for filling. Up to this time great difficulty has been found in the wet season in maintaining tracks and unloading cars, and the cost of experimental work done by the Isthmian Canal Commission was quickly and greatly increased when the rainy season came on.

The estimated average output above mentioned could easily be reached and even exceeded in a favorable climate, and in material suitable for steam-shovel work; but at Panama only three or four months each year can be called dry, and in the remaining months two or three times as much rainfall is concentrated as occurs in the entire year in the central and eastern parts of the United States. As to the material, the greater part of it will require blasting, while much of it is hard rock. The average output estimated for shovels at the canal is

double that realized in mixed materials in several operations in the United States.

believe the time required to excavate the Culebra the sea-level canal will be much greater than by the Board and not less than fifteen years. conclusion has been reached by considering the cut as a whole, studying the possible arrangeof tracks and distribution of plant, and also with reference to the heaviest portion, about 4,300 ft. gth.

lock canal with summit level at elevation 60 would 72,800,000 cu. yds. of excavation from the central and assuming the time will be proportional to the t to be excavated from this mass and that the sea- canal would require fifteen years, the time required complete the lock canal with summit level at elevation would be ten years. On the same basis the time re- for the lock canal with summit level at elevation which requires the excavation of 53,800,000 cu. yds. from the central mass, would be about 7½ years, a conclusion which is verified by a study of conditions in the heaviest portion; but before accepting this period as the time required to build the canal consideration must be given to the question of time required to build the locks.

For the 85-ft. level the greatest amount of lock excavation and the greatest amount of lock masonry will be required at Gatun. The amount of excavation for this lock, embracing a distance of 3,136 lin. ft., measured along the canal axis, will be 3,660,000 cu. yds., and the average width of the excavation will not differ greatly from the average width of the Culebra cut in the heaviest section. The excavation of the corresponding length of the heaviest section of the Culebra cut in fifteen years will require the removal of 933,000 cu. yds. per year. If this rate can be maintained at the lock site at Gatun the excavation would require four years. It does not appear that the materials at Gatun are any less favorable to excavate than at Culebra, while the distance to a dumping ground would be less, and the excavating plant could be arranged for more effective use, and therefore a somewhat better rate should be reached at Gatun; but if no reduction be made on account of these better conditions the estimated time will be on a more conservative basis than the estimate of the time for the sea-level canal.

The amount of concrete masonry required for the Gatun locks will be about 1,300,000 cu. yds. This would be the greatest mass of masonry built in modern times. Like the excavation of the Culebra cut it will require special organization and the best plant. Plant and materials should be accumulated in advance while the excavation is being made. With such preparation a very rapid construction is practicable. In recent work in the United States an average of about 400 cu. yds. per day was maintained for a considerable period with a single mixing plant, and a maximum was reached of more than 800 cu. yds. in one day. At the Gatun locks, with their three main walls aggregating more than 9,000 lin. ft., 20 mixing plants or even more could be set up and operated to advantage, and at the average rate of 400 cu. yds. per plant per day the daily rate would be 8,000 cu. yds. But assuming a very large reduction from this—that only ten of these plants were operated simultaneously, with an average output of only 250 cu. yds. per day for each—the daily rate would be 2,500 cu. yds., which is certainly easily attainable and may be much exceeded. At this rate the entire amount of concrete would be placed in 520 working days, or 2¼ years. The materials for this daily output of concrete would amount to about 4,000 tons, or, say, 125 carloads. This is about one-fifteenth of the weight of the excavated materials to be moved daily from the Culebra cut, and it does not appear to offer any special difficulty.

The largest item of work remaining is the erection of the gates, of which 14 pairs will be required for the duplicate flight. At the Poe lock of the St. Marys Falls Canal 5 pairs of gates were erected with a small force and a single plant in 16½ months, of which about 6 months were winter, and in that extremely cold climate little progress could then be made. Deducting half of this period, the period of effective work was not more than 13½ months, giving less than three months as the time required for the erection of one pair of gates. Not less than five plants should be provided for the 14 pairs of gates at Gatun, and if we assume five months instead of three months as the period required for one pair on account of the greater size of the gates, the total time for all the gates at this lock would be 15 months, or 1¼ years. As the plants are not expensive, they might be further increased in number, and if seven were employed the time required would be only 10 months, or, say, one year. As this work could be done under roof, little time need be lost on account of rain.

The periods above mentioned aggregate 7¼ to 7½ years, which is less than required for the Culebra cut; but this aggregate results from assuming that excavation would be entirely completed before making concrete was commenced, and that the concrete would be entirely completed before the erection of the gates was taken up. These operations would, in fact, overlap and, to a considerable extent, be carried on together, effecting considerable reduction in total time.

Making due allowance, as before indicated, for possible delays in the concurrent execution of several works, and taking a total of nine years for the entire work, we arrive at a period which we believe to be far more conservative than the period of 15 years for a sea-level canal. A saving of at least six years will result from the adoption of the plan herein recommended instead of a sea-level plan.

RELATIVE TIME OF TRANSIT.

In the sea-level canal it will be necessary for one of two ships of medium or large size about to meet to make fast to mooring piles or posts while the other passes at reduced speed. In the Suez Canal this is done in all cases, and at regular mooring places where facilities are supplied. At these mooring places, which are usually about four miles apart, the canal is widened for a distance of about 2,400 ft. from the ordinary bottom width of about 108 ft. to about 150 ft. The latter is the bottom width proposed for the greater part of the sea-level canal, but as the Panama Canal is intended to provide for larger ships than any now passing through the Suez Canal, it is assumed that passing places will be made in the 150-ft. channels of the former, although the estimates of cost do not provide for them. In the Suez Canal no meetings are allowed where the canal passes through rock. It is here assumed that passing places will be made at Panama in all materials, unless the bottom width is as much as 200 ft. with sides vertical and continuous for a considerable distance, as in the Culebra cut, or unless, if the sides are flat slopes, the bottom width is 300 ft. or more. In the Culebra cut, where the sides are vertical, it can be arranged to make a ship fast anywhere. In channels 300 ft. wide ships can pass each other at reduced speed without stopping. In widths of 500 ft. or more it will not be necessary for either to reduce speed.

The broad channels afforded by the lock canal with summit level at elevation 85 will enable ships to pass through them at much greater speeds and with much greater safety than in the narrow channels of the sea-level canal, and as there will be only a small proportion of channel less than 300 ft. wide in the lock canal, very little loss of time will occur at meeting points; but in the sea-level canal, with its narrow channel all the way across the Isthmus, the time lost at meeting points will be considerable, even with moderate traffic, and will increase with great rapidity as traffic increases. With ships of such size as those of the principal lines between western Europe and the Orient, the time lost by meetings and by the lower speeds through the narrow waterway of the sea-level canal would be greater than the time required for lockage through the several locks of the canal. With ships approaching in dimensions those contemplated by the act of Congress authorizing the building of an isthmian canal, the transit across the Isthmus, even with a small traffic, would require more time in the proposed sea-level canal than in the lock canal herein recommended, and with a heavy traffic the loss of time would be an important feature.

In the narrow channels of the sea-level canal, with its large proportion of curves, night navigation will be more hazardous than by day, and ships will probably move at lower speed than assumed for the calculation of time of transit. Unless ships arrive very early in the day, they will not be able to pass through the canal by daylight on the day of arrival, but will have to submit to the delays of night navigation or tie up until the next day.

CAPACITY FOR TRAFFIC OF THE TWO PROJECTS.

The best example of a ship canal with locks and modern equipment and a large traffic is the St. Marys Falls Canal, and it is therefore the best precedent in discussing the traffic capacity of a lock canal at Panama. The claim is made in the report of the Board that it is not a maritime canal, and that for this reason experience there is not a safe guide for the consideration of a canal for seagoing ships. This demands most careful attention. The other great ship canals with locks are the Manchester, the Amsterdam and the Kaiser Wilhelm or Kiel, all of which connect with the sea at one or both ends.

The traffic through the Manchester Canal in the last year reported, 1900, was 1,492,320 tons net register. The number of vessels was 5,362, giving an average tonnage of only 278. Exact figures as to the present tonnage are not available, but it is probably about one-third more.

The traffic through the Kaiser Wilhelm Canal during the year ending March 31, 1905, was 5,720,477 tons in 32,623 vessels having an average tonnage of 162. A large proportion of the larger ships were German war vessels, 648 of these having passed through the canal in that year.

There are two canals at the St. Marys Falls, the canal on the American side having two independent locks, one called the Weitzel lock, 515 ft. long, 60 ft. wide at the gates (80 ft. in chamber), and 17 ft. over the sills; the other, called the Poe lock, 800 ft. long, 100 ft. wide, and 22 ft. over the sills. The canal on the Canadian side has a lock 900 ft. long, 60 ft. wide, with 22 ft. over the sills. In 1905, 19% of the tonnage passed through the Weitzel lock, 66% through the Poe lock, and 15% through the Canadian lock. The sailing route is a little shorter via the American canal, and the canal has nearly vertical sides; in the Canadian canal the sides have a slope of 4 on 1, and floating fenders are in use to keep vessels from injury, but are not satisfactory; for these and other reasons the greater part of the traffic passes through the American canal. The depth of water on the sills of the Weitzel lock is not sufficient for the larger vessels when loaded, and it is used mostly by vessels of smaller size. The locks therefore effect a classification of vessels, the largest always passing the Poe or the Canadian lock when loaded, and usually when light. None of the locks is worked to its full capacity.

In 1905 the total net registered tonnage passing through the two canals was 36,617,699 tons, the number of vessel passages (excluding scows, etc., not registered) being 20,460, and the average tonnage 1,790. The net registered tonnage through the Poe lock was 24,176,472, the number of vessels 9,374, and the average tonnage 2,579.

These comparisons appear more clearly in the accompanying table where the preceding figures are collected. The tonnage through the St. Marys Falls Canal is net register, and it is presumed the tonnage for the other canals is of the same measurement:

Canal.	Year.	Number of vessel passages.	Tonnage.	Average tonnage of vessels.
[1]Manchester	1900	5,362	1,492,320	278
[2]Manchester	1900	2,900	1,230,784	424
[3]Kaiser Wilhelm..	1905	32,623	5,270,477	162
[4]St. Mary's Falls..	1905	20,346	36,617,699	1,790
[5]St. Mary's Falls..	1905	9,374	24,176,472	2,597

[1]All vessels.
[2]Manchester trade only.
[3]Year ending March 31.
[4]All locks.
[5]Poe lock only.

After an inspection of this table a claim that experience in regard to the navigation of lock canals is to be looked for at the Manchester or the Kaiser Wilhelm canals rather than the St. Marys Falls Canal would appear preposterous. It would require only 480 vessels of the average size passing the Poe lock during the present year to equal the tonnage of the 2,900 vessels passing through the Manchester Canal in 1900, and only 2,044 to equal the tonnage of the 32,623 vessels passing the Kaiser Wilhelm Canal during the last year.

Having in consideration all the forgoing facts, we believe not only that the experience gained at the St. Marys Falls Canal is applicable to the navigation of the Panama Canal, but that it is of vastly more value than any or all experience in the foreign lock canals. The amount and character of traffic through the foreign canals does not suffice to prove the capacity and suitability of a lock canal for a great traffic, because none of them carries such a traffic, but the St. Marys Falls Canal supplies the deficiency and makes the proof complete and, indeed, overwhelming.

Nevertheless, it is contended by the Board that the St. Marys Falls Canal is used by ships that frequently pass it, and that the pilots and crews are familiar with all the operations of passing locks, while the Panama Canal would be traversed by ships with crews ignorant of these matters, and therefore the record of safety and capacity so completely established in the American canal could not be paralleled at Panama, but, on the other hand, the most imminent risk and vexatious delays would be incurred at all times. We cannot help believing that due consideration concerning the things required to be done to pass a canal lock would dispel these apprehensions.

The movement of a ship is controlled in both cases by signals transmitted from the pilot house to the engine room; the engineer must check, stop, start, etc., when ordered; he is accustomed to doing so quickly, whether at sea, in a canal, or in a harbor, whether approaching a landing or a dock. The engines are practically of the same type. As a ship nears a lock, lines will be put out, carried by the lock tenders and placed on snubbing posts as required, the ship's sailors having only to haul in, to make fast, to slack off or pay out, which they ought to do more skillfully than the less trained deck hands on lake ships. All of these operations will be required at the passing places in a sea-level canal and under more difficult conditions than at locks. Furthermore, on each ship while in the canal there will be a pilot whose entire time will be given to the handling of ships in the canal and who will be not less skillful than the lake pilot who is in a lock canal for only an hour two or three times a month.

The estimate of the Board as to the possible number of lockages per day "perhaps not exceeding ten per lock or twenty per pair" is at variance with American experience. As many as 36 lockages have been made at the Poe lock in one day, passing 93 vessels. The estimate of lockage capacity given in Appendix L is based on actual performance, which the estimate of the Board ignores.

The experience at the St. Marys Falls Canal is particularly important in establishing the capacity of a lock canal for traffic, because its nearest parallel in point of magnitude of traffic is a canal with no lock, viz., the Suez Canal. The tonnage through the Suez Canal in 1904 was 13,401,835 tons, Danube measurement, or about 11,500,000 tons net register, since the Danube measure-

ment is 16 to 20% greater. This is less than one-third the tonnage through the St. Marys Falls Canal in 1905 and less than half the tonnage through the Poe lock alone. Taking into account the short navigation season at the St. Marys Falls Canal, the tonnage per month during the navigation period of 1905 was three times as much through the Poe lock alone as at Suez.

The Suez Canal is traversed almost exclusively by sea-going ships making long voyages, and therefore of large size. The average measurement of the 4,237 vessels passing in 1904, about 2,700 tons net register, is more than six times that of the vessels passing through the Manchester Canal to its terminus in 1900, and about sixteen times that of the vessels passing through the Kaiser Wilhelm Canal during the last year. It is about 50% greater than the average tonnage of the vessels passing the St. Marys Falls Canal during 1905, but only 10.5% greater than the average of those passing the Poe lock. The portion of the tonnage through the Poe lock which is carried in vessels equal to or exceeding the average measurement of the ships passing the Suez Canal is largely in excess of the total tonnage at Suez.

Finally, the aggregate tonnage passing all the four foreign canals above mentioned is much less than that passing the St. Marys Falls Canal, and is even less than that passing one only of the three locks in use there. The average tonnage of the vessels in these foreign canals is but little more than one-fourth the average of those passing the St. Marys Falls Canal and but little more than one-sixth the average of those passing the Poe lock. With these facts in mind there can be no need of further argument that this canal, although neither end touches salt water, furnishes abundant proof of the suitability of a canal with locks to serve a great commerce carried in ships of any size.

The duplicate locks of the Panama Canal will afford convenient passage for an annual net registered tonnage of 80,000,000.

SAFETY OF LOCKS AND OTHER STRUCTURES.

The most plausible arguments advanced by advocates of a sea-level canal to justify its greater cost and the greater time required to build it are the alleged danger of carrying away the lock gates at either end of the summit level if a ship moving at speed should strike them, and the possible damage to structures through malice or in time of war.

An accident to gates, if it occurs, is most likely to result from a mistake in the engine room, the engineer sending the vessel ahead when the pilot signals to back, and then the pilot, noticing that the ship's speed is not being reduced and not realizing that the previous signal is not being carried out, signals for full power or perhaps signals so rapidly that he cannot be understood. One or the other of these successions of events has usually taken place when a ship has run into lock gates. The carrying away of a lock gate occurs but rarely, but it has occurred three times in the Manchester Canal. It has never occurred in the St. Marys Falls Canal.

In the Manchester Canal the gates at the lower end of the lock were struck, the upper gates being open, the ship moving downstream, but in all cases the operating force was able to get the gates at the head of the lock closed, or so nearly closed that they came together and held back the water in the canal. If such an event should occur at Panama, where the locks are in duplicate, traffic through the injured lock would be suspended until repairs could be made. With duplicate gates in stock the repairs could probably be made and traffic resumed through the injured lock without a prolonged delay. In the meantime, traffic would be continued through the duplicate lock, and although, if the traffic were great, it would be subject to some inconvenience, yet it would be maintained.

If, however, the gates supporting the summit level should be carried away and the current flow unobstructed through the locks with no means in readiness to stop it, such, for example, as a movable dam, the result would be very serious indeed. It would require many days to lower the level of Lake Gatún sufficiently to render the task of closing the opening through the lock easy, and in the meantime the channel and the works below the lock might be seriously damaged and navigation suspended for weeks or months. The chances for such a disaster are so small that if the Panama Canal were intended for commercial purposes only, the great additional expenditure required to make it a sea-level canal would have few advocates, but the possible need of the canal for the passage of ships in time of war strengthens the argument for a sea-level canal and makes it necessary to consider with care the chances of such an event in ordinary canal operation, the facilities for handling and controlling the movement of ships which may be used, the precautions for safety which may be introduced in the operation of the locks, and the constructions which may be supplied to close off the current should it be set up.

We believe that in no ship canal in the world has such a disaster occurred as that imagined for the Panama Canal. If the accidents at the Manchester Canal show that gates may be struck and destroyed, they also show that disaster may be averted even without special safeguards. Of all the possible movements of a ship at canal locks the one that involves the most danger of opening a summit level is when a ship bound down in that level approaches a lock, but by proper safeguards this can be made very small. If a gate is struck by a ship upward bound the water pressure on the opposite side of the gate helps to resist the blow. By the use of two pairs of gates at each end of the summit lock all danger of opening the summit level by a blow on the downstream side of the lower gates is eliminated, as will be shown a little further on.

The canal construction should provide long approach walls at each end of every lock or flight of locks so that lines can be put out quickly and handled readily and the ship held under perfect control. For this important purpose a long solid pier with suitable snubbing posts is vastly superior to mooring piles and floats, such as are used in some foreign canals. No canal in Europe is adequately provided in this respect, and the apprehensions of some members of the Board in regard to the hazards of navigation through lock canals may be due to the fact that their experience has been entirely with canals having this radical defect. With suitable approach piers and with rules duly enforced requiring ships to put out lines on arriving at the pier and to reduce speed to two miles per hour when moving along it, or to stop altogether several hundred feet from the lock, a great degree of security can be obtained. Such approach piers are provided in the lock plan herein recommended.

This plan also provides two pairs of gates at the head and two at the foot of each summit lock, so that a ship will always find two pairs of gates shut against it.

If the summit level is terminated by a single lock and the lower gates is struck by a ship upward bound, the gates at the upper end of the lock being open, the lower pair of gates at the foot of the lock having water pressure back of them will absorb the blow, and even if they are wrecked the second pair of gates, some 80 ft. distant, will not be reached. The resistance offered by the first gates will almost surely stop the ship, and the rush of the mass of water, 80 ft. in length between the two gates, will insure stoppage before it can reach the second pair. If the lower end of the lock is open and the upward-bound ship strikes the first pair of gates at the upper end of the lock its motion will be stopped by these gates, the miter wall, and the water, and the second pair of gates will be left intact. We believe, therefore, that, by the use of duplicate or safety gates at each end of the summit lock, all danger of opening the summit level by an upward-bound ship will be eliminated.

If a downward-bound ship is approaching the gates from the summit level it will find at least two pairs of gates closed against it, of which the first will be sustaining no water pressure to weaken the strength available to stop the ship. While this case does not afford the absolute security shown in the case of ships moving upstream, the possibility that the ship will so completely wreck the first pair of gates as to continue its course to the second and seriously harm it is extremely small. A large lock gate is a massive structure, not easily wrecked. The gates of the Poe lock have been struck three times and injured more or less, but they continued to support the summit level.

The provision of duplicate gates at each end of a lock herein adopted is an unusual precaution. It has been recently adopted in part at the St. Marys Falls Canal, where duplicate gates are now operated regularly at the lower end of the Poe lock, but the upper end is not similarly protected. In the additional lock now projected at that canal safety gates are to be provided at each end. The approach piers, the extent of which greatly affect the safety of a lock, are excellent at the St. Marys Falls Canal and far better than at any other ship canal, and doubtless have contributed to the remarkable record of immunity from serious accidents.

This canal has now been in operation a little more than fifty years and a traffic aggregating about 360,000,000 tons net register has passed through it, with no accidents seriously obstructing navigation. It is the best example existing not only of the capacity of a lock canal for a great traffic but of the safety with which this traffic can be handled with suitable equipment.

In view of these facts relating to the operation of canals not as well provided with safety appliances as proposed for the Panama Canal it appears fanciful to enlarge on the dangers of a lock system; but even the small risk which a lively imagination might still assign to a lock canal can be substantially diminished, since it is not impracticable to stop the flow from a summit level, if once set up. Several devices have been built to control the flow of water from the summit level in case lock gates should be carried away. More than forty years ago a pair of gates provided with powerful brakes to check their movement while closing in a current was placed about 3,000 ft. above the locks in the St. Marys Falls Canal. The gates were removed about fifteen years later when the canal was deepened, before any occasion had arisen to use them for the purpose intended. When the channel was deepened a construction was adopted consisting of a series of wickets, each so small that its movement could be controlled by machinery of moderate power. The wickets were carried by a swing bridge and when not in use the bridge was open and the wickets were then on land, where they could be inspected and repaired. The canal force was trained regularly in the handling of this device so that they might work promptly in case of actual need. For such experimental practice the same procedure was followed as in a real emergency, viz., the bridge was swung across the canal and the wickets lowered one by one, their lower ends resting against a sill at the bottom of the canal, the upper ends supported by the bridge. After about eighteen months the canal was again deepened and the device removed before any accident requiring its use had occurred. A modified form of the device was built at the Canadian canal at the St. Marys Falls about ten years ago, but is yet unused, and another is about to be supplied for the American canal. The problem of working out a satisfactory device for this purpose in the deeper channel of the Panama Canal is a difficult one, but no doubt is entertained that a solution can be made. For such appliances the sum of $2,000,000 is included in the estimate of cost.

A lock may suffer other injuries, and will require repairs, during which navigation through it may be interrupted. For this reason, principally, duplicate locks are provided, so that if one is under repair navigation may continue uninterrupted through the other. It is seldom that a lock is put out of use, and the simultaneous disabling of two would be very unlikely.

The canal structures most exposed to injury through malice or in time of war are the locks and wasteways.

In the sea-level canal there would be three such points—the tide lock at Ancon, the sluices at the Gamboa dam, and those between Ancon and Pedro Miguel, the last named being of small importance. There will be five in the lock canal herein advocated—the locks at Gatun, Pedro Miguel, and Sosa, the sluices at the Gatun dam, and the sluices or wasteways in the Ancon-Sosa saddle. The latter is so small and may be so securely founded on rock but little below the level of the canal that no possible injury to the structure would interfere seriously with navigation. The Ancon lock of the sea-level canal and the Sosa locks of the summit-level canal are equally exposed to attack by a naval force.

While it is conceivable that a malicious person or a crank might carry enough concealed high explosive to injure a lock gate or a sluice, experience of many years of perfect immunity in all the ship canals shows that this is not a real danger. The only disaster to be seriously considered is one that might be inflicted by a hostile force in time of war. If the enemy had control of the coast, or occupied territory inland in the vicinity of the canal, enough high explosive could be carried through the tropical jungle by a small force to destroy any of the lock gates or sluiceways, or to sink a ship. In order to open the summit level effectively and cause a suspension of navigation for a long time, it would not only be necessary to destroy two pairs of gates, but also the device already referred to for closing the channel in a current. So large a force and so much time would be required to do all this that it could be effected only by a force superior to the strong guard which in time of war would certainly be stationed at every important canal structure.

It has been suggested that a vessel carrying a large quantity of concealed dynamite could be exploded in a lock and wreck not only the gates, but the masonry. While the execution of such a plan is extremely improbable, there are three places where it might be attempted in a summit-level canal and one in a sea-level canal. In either case the duplicate system of locks would reduce the hazard very much.

But it must be remembered that it is easily possible to block a sea-level canal by the sinking of a vessel in its channel, either by design or by accident, such an accident, for instance, as that which caused the steamship "Chatham" to absolutely block the Suez Canal and suspend all traffic through it for a period of nine days, from Sept. 27 to Oct. 6, 1905.

This accident occurred in time of peace in a sea-level canal, 36 years after its completion. During the period of 50 years since it was built there has been no such protracted interruption of traffic in the lock canal connecting Lake Superior with the lower lakes, and the delays in the channels away from the locks have constituted the most serious interruption to traffic on that waterway.

It is therefore evident that the structures are not the only vulnerable points in a waterway across the Isthmus. The locks and wasteways could be much more readily guarded than the whole length of the canal. At almost any point on the sea-level canal the attempt might be made to explode dynamite under a passing ship, which, if successful, would close the narrow channel effectively. There are many places on the route where this could be done more safely to the hostile party than at the locks. To this danger ships would be much more liable in the narrow channel of the sea-level canal than in the broad waterway of which the lock canal mainly consists.

We believe that unless the canal were declared neutral by general agreement among civilized nations the maintenance of navigation through it in time of war and with an active hostile force in the vicinity would be difficult;

but the danger under this condition does not differ greatly whether the canal be a sea-level or a lock canal.

Possible injury by earthquakes to a canal across the Isthmus has received much discussion and much has been made of it by opponents of any canal. It was treated fully and fairly by the first Isthmian Canal Commission, and the following opinion expressed, which is entirely applicable to the lock canal herein advocated, and in which we concur:

The works of the canal will nearly all of them be underground. Even the dams are low compared with the general surface of the country, and, with their broad and massive foundations, may be said to form part of the ground itself, as they are intended to do. The locks will all be founded on rock. It does not seem probable that works of this kind are in any serious danger of destruction by earthquakes in a country where lofty churches of masonry have escaped with a few minor injuries.

A large number of engineers on both continents, including four members of this Board, have in previous years concurred in recommending lock canals as feasible and adequate waterways across the Isthmus. While the ships to be provided for in the present projects are larger, the increase is not so radical as to make the forms of construction which were feasible and adequate for the ships then contemplated "altogether beyond the limit of prudent design for safe operation" and without "reasonable assurance of safe and uninterrupted navigation" for the ships now under consideration, as asserted by the Board.

RELATIVE SAFETY OF SHIPS IN THE TWO TYPES OF CANAL.

A lock is a short section of canal, with vertical sides, in which ships are moved at a low speed and under perfect control. A ship is in much less danger of injury in a canal lock than when landing at a pier in the most favorable conditions with no wind or current. Experience at the St. Marys Falls Canal, where no vessel has been seriously injured in a lock during 50 years of continuous use, should be conclusive on this point. Danger to ships in a canal is not at the locks, where they are moving slowly and under control, but in the excavated channels elsewhere through which they pass at speed, and where, if the width is insufficient, groundings are likely to happen, and if the sides are rocky and rough, serious injury to the ship will probably result.

What has been said above as to the relative danger to ships in locks and in narrow channels is equally true in regard to delays. From the records of the Suez Canal there was obtained for the first Isthmian Canal Commission a statement showing delays to traffic from ships grounding during a period of eight months, from January to August, 1899, inclusive. No delay of less than six hours was included. Groundings of more than six hours were 15 in number, the aggregate delays to the grounded ships being 292 hours 29 minutes. In 14 of the 15 cases the channel was blocked so that other ships could not pass, the total time during which the canal was blocked being 185 hours 46 minutes.

With duplicate locks, as proposed for the Panama Canal, navigation would seldom be delayed at the locks, as it would be extremely improbable that both of them would be out of use at the same time. In an appendix information is also given respecting delays to navigation in the excavated channels of the St. Marys and St. Clair rivers. These channels are much wider than the sea-level canal would be, yet they have been blocked on several occasions. In one instance, when the blockade continued for five days, 332 vessels were delayed, and the loss to navigation amounted to a large sum, estimated to be $600,000. The loss in such a case increases very rapidly with the density of the traffic. In comparing the two projects it must be kept in mind that the broad channels and duplicate locks make a blockade almost impossible on the summit-level canal, while the narrow waterway of the sea-level canal is far more liable to interruption.

ESTIMATED COST FOR PROJECT RECOMMENDED.

An abstract of the estimated cost of the canal with summit level at elevation 85, using the unit prices adopted by the Board, is as follows:

	Miles.	Cost.
Breakwaters in Limon Bay	...	$5,300,000
Channel in Limon Bay	4.55	1,245,000
Limon Bay to Gatun locks	2.60	3,921,000
Gatun locks, including excavation and back filling	.59	15,691,000
Approach walls to Gatun locks	...	500,000
Gatun dam and spillway		7,788,000
Gatun to Obispo	23.51	5,005,000
Obispo to Pedro Miguel	8.13	43,337,000
Pedro Miguel locks, including excavation and back filling	.23	6,988,000
Approach walls to Pedro Miguel locks	...	300,000
Pedro Miguel to Sosa locks	5.47	420,000
Sosa locks, including excavation and back filling	.41	13,092,000
Approach walls to Sosa locks	...	450,000
Sosa locks to deep water in Panama Bay	4.23	1,939,000
La Boca dam	...	1,675,000
Ancon-Sosa and Ancon-Corozal dams	...	1,645,000
Diversion channels between Obispo and Pedro Miguel	...	850,000
Diversion channel and regulating works at Ancon	...	275,000
Diversion of Panama Railroad	...	3,700,000
Movable dams at ends of summit level	...	2,000,000
Land damages	...	300,000
	49.72	$116,421,000
Administration, engineering and contingencies, but not including interest during construction, sanitation or expenses of Zone government	...	23,284,200
Total estimated cost	...	$139,705,200

Neither the foregoing estimates nor that for the sea-level canal contains an allowance for the fortification of the route.

The total amount of excavation from the canal prism is 95,955,000 cu. yds., of which 53,765,000 cu. yds. are from the Culebra cut.

An allowance of 20% for administration, engineering and contingencies is provided, as in the Board's estimate for the sea-level canal. In the estimates of the Isthmian Canal Commission of 1899-1901 the same allowance was made, but this allowance was to cover somewhat different items. The allowance in the present estimates does not cover sanitation and Zone government, which were included in the allowance in the former estimate, but does include another item which may prove to be a large one, viz.: revetments of the sides of the canal in the Culebra cut.

In the project of the commission of 1899-1901 the concrete retaining wall was to extend the entire length of the narrow section through the Culebra cut, which, in the plans of that commission, was 7.91 miles, and was estimated to cost, exclusive of the 20% allowance, $9,619,304. It is now believed that for a large part of the distance through the Culebra cut the rock sides will be sound enough to stand vertical and remain smooth if properly formed by channeling machines, and where this is the case a revetment will not be required, while for the remaining distance some form of revetment will be necessary; it is also believed that the extent and best form of revetment can only be determined by a study of the materials actually seen in place as the excavation proceeds, and that items of this character are appropriately considered as contingencies. It should be pointed out that the cost of revetment on the sea-level canal would be greater than for the summit-level canal by the reason of the greater length of narrow section in the former. In the plan for a summit-level canal the length of the narrow section is reduced to 4.70 miles by widening to 300 ft. at each end, while in the sea-level canal there would be 19.47 miles of channel 200 ft. wide excavated partly or wholly in rock.

COST OF MAINTENANCE AND OPERATION.

In a comparison of the cost of maintenance and operation of a lock and of a sea-level canal there is in the case of the lock canal the additional cost of the force for operating the greater number of locks, and in the sea-level canal the extra cost of the force which must be kept at the meeting places where ships are moored, and of dredging the canal and diversion channels to maintain their depths.

The lock canal will have locks at three places, each of which will require a force of attendants, while the sea-level canal will have only one such place. On the other hand, there will be no specially prepared meeting places for ships on the lock canal except at the locks, while on the sea-level canal seven such places will be required, assuming them to be five miles apart, and the force required to attend to ships mooring at these places will to a considerable extent offset the extra force required at the locks of the lock canal. To maintain the depth and size of the 40 miles of sea-level canal between shore lines, and of the still greater length of diversion channels, will entail a greater annual expense, as the canal and channels are designed to receive directly the silt of all tributary streams on which dams are not to be built. The lock canal will cost very little for the maintenance of its channels between shore lines, because nearly all the streams empty into lakes where the silt will settle far from the canal. Any dredging required to maintain harbor channels will be common to both plans.

This brief analysis indicates that the sea-level canal will cost no less for maintenance and operation than the lock canal, and this view is supported by estimates in detail of cost of maintenance and operation of the two types of canals.

SAFETY OF DAMS.

Reference is made in the Board's discussion to the subsurface material at Gatun, which is stated to be "in large part of a comparatively fine character, consisting of sand and clay in varying portions and in various degrees of admixture, but the borings have also shown coarse sand and gravel."

In order to make this statement express clearly the actual situation the addition should be made that the coarse sand and gravel are found in the bottom of the narrower of the two deep gorges in the rock, and overlying them are 200 ft. in thickness of finer materials, the impervious character of which will prevent the waters in the lake from having access to the deep-lying sand and gravel in any appreciable quantity. Actual experience with dams and experiments on the filtration of water through sand and finer materials show that the amount of water filtering under such circumstances will be too small to affect in any way the stability of the dam.

The subsurface sands on the southerly slope of Long Island, from which a portion of the water supply of the Borough of Brooklyn is taken, and to which the Board refers, are noted for their extent and for their porosity, due to the size and uniformity of their grains. By far the larger part of this water supply is taken from the Ridgewood system of works, which comprises both surface and subsurface sources. The quantity taken from the ground equals approximately 70 cu. ft. per second, a volume which is small in comparison with the 1,477 cu. ft. per second available for lockage in the canal plan recommended. This quantity, however, is collected in a length of 21.3 miles, so that the quantity per mile is only about 3½ cu. ft. per second, or, in a length equivalent to that of the Gatun dam, about 5½ cu. ft. per second. If instead of using the total length of the Gatun dam, only the parts of the length which cross the alluvial valleys were included, the proportionate quantity would be still smaller. If any inferences of value are to be drawn from a comparison of conditions at Long Island with those at the dam sites at the Isthmus, where clay is the predominating material, they are that even under conditions favorable to filtration the amount of water passing through a considerable length of ground is comparatively small, and that water may filter through and be taken from the ground without disturbing either the earth through which it filters or that from which it is taken.

The extent of the sand and gravel deposit in the lower part of one of the rock gorges at Gatun is limited, and if it be assumed that instead of being covered with an impervious blanket 200 ft. thick the water above and below the dam has free access to the porous material, and if the further assumption be made that the material has as much filtering capacity as a coarse uniform sand or a coarse unscreened gravel or a typical Long Island sand, the quantity of water which would pass through it would be very much restricted by the long distance covered by the dam, and would not exceed 2 cu. ft. per second.

CONCLUSIONS AND RECOMMENDATIONS.

The greater cost of the proposed sea-level canal—upward of $100,000,000 more than that of the lock canal herein advocated—is not a trifling sum, even for the resources of the United States. If such an outlay is incurred a greatly superior waterway should be obtained or the expenditure will be unwise and the result discreditable.

The question of relative safety of the two types of canal must be considered with reference both to the waterway and the traffic.

It has been shown that the risk of serious injury to a well-equipped canal lock has been found very small, and with the additional and unusual precautionary constructions proposed for the lock canal at Panama it will be almost inappreciable, except in time of war. At such a time either form of canal would require efficient military protection, and such protection is as practicable for a lock canal with a broad waterway as for the narrow channel of the sea-level canal. In the former case military protection would be specially required at the locks and in the narrow portion of the Culebra cut; in the latter case, the advantage of a smaller number of locks to be guarded would be fully offset by the greater difficulty of guarding the entire length of narrow channel, which would extend from sea to sea.

It has been shown by ample experience that ships are far more liable to delay and injury while traversing artificial channels at considerable speed than when passing locks where they move slowly and are under perfect control. The narrower the channel the greater the danger of collisions, groundings, blockades and injuries to ships.

The broad channels of which the lock canal will mainly consist will permit vessels to move at greater speed than would be safe in a narrow channel. Although the Board apparently questions this, its truth is self-evident, and, moreover, is established beyond a doubt by abundant and long-continued experience. Ships meeting in these broad channels will pass in safety with little if any reduction of speed, while in the narrow sea-level canal one of two meeting ships, unless of small size, would have to stop and make fast to the bank at a regular meeting place and remain there until the other passed at reduced speed, involving both delay and appreciable risk to the ships.

In consequence of the lower speed and the delays of various kinds in the narrow sea-level canal, ships of large size would consume more time in passing through it than would be required in a lock canal; and with a heavy traffic this would be true for ships of even moderate size, for the reason that more time would be lost in the narrow channel of the former than at the locks of the latter. As the delays at meetings in the sea-level canal would increase rapidly with the traffic, they would become insupportable with a traffic much smaller than the lock canal would provide for. The sea-level canal may therefore be called "provisional" with far more propriety than the lock canal.

In view of the unquestioned fact that the lock canal herein advocated will cost about $100,000,000 less than the proposed sea-level canal; believing that it can be built in much less time; that it will afford a better

navigation; that it will be adequate for all its uses for a longer time, and can be enlarged, if need should arise, with greater facility and less cost, we recommend the lock canal at elevation 85 for adoption by the United States.

Respectfully submitted, Alfred Noble, Henry L. Abbot, Frederic P. Stearns, Joseph Ripley, Isham Randolph.

SOME FEATURES OF MODERN EUROPEAN GAS HOLDER DESIGN.

By K. A. Müllenhoff.*

In Engineering News of Oct. 26, 1905, there was a very interesting description of the erection and construction of a modern American gas-holder. Though there are only slight differences in the best European practice, there are several improvements in the general design that it may be interesting to describe.

As the inner holder shell is always covered with water on the inner side, it is nearly impossible

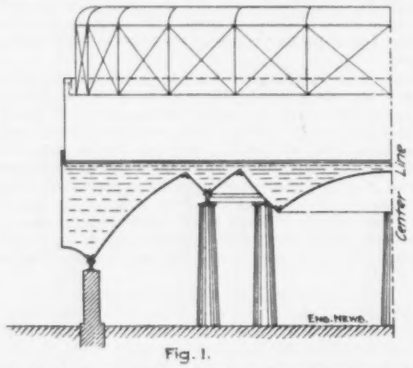


Fig. 1.

to inspect it, and to detect any leakages that may occur, be they from rust or from inefficient workmanship. At the same time, the holder covers a great area, very valuable in big towns or in industrial works with a gas plant of their own, and the greater amount of the water contained in the tank is of no use at all.

With these facts in mind, Professor Intze, of Aachen, Germany, who died only recently, far too early for the good of the civil engineering profession, conceived the idea of making the inner shell or tank similar to his system of water tanks, as shown in the sketch Fig. 1. The bottom of this Intze tank consists of several conical or spherical surfaces, arranged in such a way that there is no, or only a very small compressive or tensile stress in the rings supporting it. It is supported by a circular wall, and for tanks of very great dimensions a second and even a third ring may be supported by columns. By making the wall high enough to admit an entrance, the whole space below the tank can be inspected, and every leak may be detected easily. Also the gas and water conduits and valves remain under control and the space not occupied by them may be employed for storage purposes or for the gas meters and in other ways.

A great number of tanks of this kind have been built, chiefly by the firm of F. A. Neuman, in Eschweiler, Germany, in various towns of Europe, for example, at Krupp's steel works at Essen and at the municipal gas-works at Vienna, with a capacity of 250,000 cu. m. (nearly 9,000,000 cu. ft.) of gas, if my memory is right. The cost of these water tanks is a little greater than that of those of the old type, but, on the other hand, there is a great saving of earthwork, so that in very many cases they will prove of great advantage.

An exact computation of the stresses in the bottom of these Intze tanks is very difficult, if not impossible. But as the designing engineer in more than three in four of all the formulas used is content with more or less rough approximations the following method may be used, and has been used in a great number of cases quite successfully:

(1) The cylindrical part:

Let r = Radius of the cylinder in centimeters or in feet.
d = distance below the surface of water in centimeters or in feet.
t = thickness of the plate in centimeters or in inches.

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then

$$\sigma = \frac{r\,d}{1{,}000\,t} \text{ in kilograms per square centimeter, or}$$

$$\sigma = \frac{r\,d}{t} \text{ 5.2 in lbs. per sq. in.}$$

(2) The bottom (Figs. 2 and 3):

Let w = the weight of water in kilograms or pounds inside or outside of a cylinder with the radius x (in centimeters or inches respectively).

α = angle of inclination of the bottom with a horizontal line at the distance x from the axis.

then

$$\sigma = \frac{w}{2\,\pi\,x d \sin\alpha} \text{ in kilograms per square centimeter or in lbs. per square inch is the radial stress at the point x. In addition to this radial stress there is also a tangential stress } \tau, \text{ which may be found by the formulas,}$$

$$\pm\frac{\sigma}{\rho} + \frac{\tau}{n} = \frac{d}{1{,}000\,t} \text{ for metric system or}$$

$$\pm\frac{\sigma}{\rho} + \frac{\tau}{n} = 0.4335\,\frac{d}{t} \text{ in English measure.}$$

ρ is the radius of curvature in the meridian in centimeters or inches.

n is the length of a normal to the curve from the curve to the axis of the tank in centimeters or in inches.

and (Fig. 4) the sign of $\frac{\sigma}{\rho}$ for bottom.

$\frac{\sigma}{\tau}$ is	I −	II −	III +	IV +
and it is	Compression / Tension	Tension / Compression	Comp. / Comp.	Tension / Tension

The compression in the supporting rings is

$$D = \frac{1}{2\,\pi}(W_o \operatorname{cotan.} a_o - W_i \operatorname{cotan.} a_i)$$

where W_o and W_i are the weight of the water in the outer and inner part of the tank and a_o and a_i the angle of inclination of the outer and inner bottom at the ring.

According to Boussinesq (Comptes rendus, vol. 97, 1883, page 843 and 1131)

$$D = \frac{3\,E\,J}{C\,r^3} \text{ where}$$

J = the moment of inertia of the ring section for the vertical axis through the center of gravity.

E = the modulus of elasticity.

C = the coefficient of safety and

r = radius of the ring.

The above formulas are taken from the last edition of the "Hütte" (1903, Vol. II., page 134), and are not yet published for English measure, so far as the writer knows.

Another important improvement has been invented by Prof. H. Müller-Breslau, of the Royal Technical High School of Berlin, and has been patented by him. It is a new design of the guide frames. Instead of using the posts at the

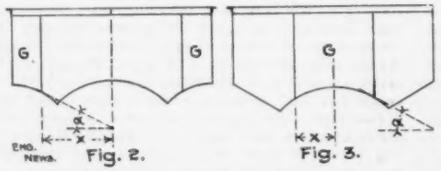

Fig. 2.

Fig. 3.

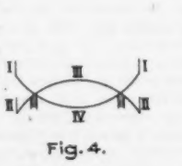

Fig. 4.

corners of the frame as guides, he uses special guides in the centers of each panel (Fig. 5). This arrangement has two great advantages: first, the brackets with the guide-rollers, are far shorter, giving a far more reliable connection between guide-frame and gas-holder, and, secondly, the distribution of forces in the framework can be calculated far more accurately, so that there is less waste of material. We have always to bear in mind that the exact computation of these guide-frames is impossible, and therefore a great margin for safety is to be used. A great number of these new guide-frames have been built by the firm of Aug. Klönne, at Dortmund, e. g., at Alkmaar, The Hague, Bromberg, Halle and Bremen, with a great saving of weight compared with the old system. Details of the computation of this guide-frame can be found in the Zeitschrift des Vereines Deutsches Ingenieure, Vol. XLII., 1898.

Another scheme to be mentioned here is the custom of enclosing the gas tank in a gasometer building, covered by a cupola or other suitable roof. In recent years this construction has not been used as much as formerly, but undoubtedly it has great advantages, as it does away with nearly all guide-frames, protects the water in the tank and the cups from freezing, and facilitates the detection of any leaks that might occur by the strong smell of the escaping gas, which can be observed only seldom in open-air gas-holders. As the gas-holder is protected from snow falling on it, the pressure in the lines and tank will be kept far more uniform; therefore in very rough climates it may prove advantageous to use these gas-holder houses, in spite of the higher cost.

THE CONDITION OF ASPHALT PAVEMENTS in the Borough of Manhattan, New York City, has been reported upon by the committee on thoroughfares of the Municipal Art Society of New York, through Mr. William S. Crandall, Chairman. The report states that there are 4,733,297 sq. yds., or 236 linear miles, of sheet asphalt in Manhattan, as compared with the total yardage of 9,837,420 and mileage of 419. The price of asphalt pavements has fallen during the past few years, "although at the expense of quality." During the same period, the maintenance guarantee has been cut down from 15 years during the period 1897 to 1900, and 10 years in 1901, to 5 years since the latter date. The average prices paid have been as follows: 1897, $3.18; 1898, $3.23; 1899, none contracted for; 1900, $3.69; 1901, $3.35; 1902, $1.55; 1903, $1.92; 1904, $2.13; 1905, $2.13. It is stated in the report that the thickness of the concrete base has been reduced from a range of 6 to 8 ins. to 4 and 5 ins., and that the binder course is neither as thick nor of as good material as formerly, and that poorer material has been used in the wearing surface. It is said that the total cost of asphalt pavements in the Borough of Manhattan has been about sixteen million dollars, and the report alleges that on many streets these pavements are in very poor repair, owing in part to the failure of the city to make the contractors comply with their guarantees for repairs.

THE COMPARATIVE MERITS OF DIFFERENT STREET PAVEMENTS.

The accompanying table has been prepared by Mr. T. J. MacCarthy, Assistant City Engineer of Holyoke, Mass., as a result of that city's experience with different types of street paving, and will be examined with interest by any of our readers concerned with this subject. Mr. MacCarthy writes us that the table was compiled on account of the large number of inquiries which were received from various sources asking the results of the city's experience in paving, and is believed to answer the questions which are most frequently asked.

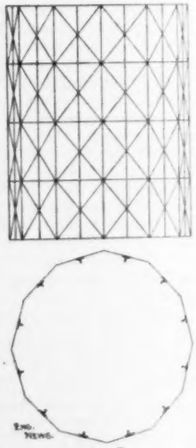

Fig. 5.

Table Showing Comparative Values of Pavements Used in Holyoke, Mass., as Determined by T. J. MacCarthy, C. E.

Kind of pavement.	When laid.	Estimated life in years.	Cost per sq. yd.	Average cost maintenance per sq. yd. per year.	Total cost per sq. yd. per year.	Grade in use.	Safe maximum grade.	Cleanliness.	Comparative slipperiness.	Noiselessness.
Granite block.....	1882	50	$2.75	$0.03	$0.085	10%	10%	40	90	10
Asphalt block	1891	15	2.83	0.02	0.21	1.5%	4%	75	40	90
Wood block	1904	..	2.83	....	....	0.5%	3.5%	70	30	100
Vitrified brick....	1897	25	2.02	....	0.08	6%	9%	80	80	35
Common brick....	1898	10	1.75	....	0.175	4%	8%	75	85	25
Sheet asphalt.....	1905	..	1.86	....	....	4%	4%	100	35	65
Bit. macadam.....	1902	..	2.25	....	....	5%	4%	85	40	75
Macadam	1894	8	0.60	0.02	0.095	8%	10%	20	100	50

Wood block, 4½-in. concrete base 1:3:7, ½-in. mortar, 3-in. block, sand filler.
Vitrified brick, 4-in. concrete base 1:3:7, 2-in. sand, 4-in. brick, Portland cement grout.
Sheet asphalt, 5-in. concrete base 1:3:7, 1-in. binder, 1½-in. wearing surface.
Bit. macadam, 4-in. broken stone, 1½-in. binder, ½-in. wearing surface.

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Probably few of our readers were surprised at the announcement last week that the St. Louis-Chicago drainage canal suit had been decided against St. Louis. In the present state of sanitary science and sanitary law, St. Louis undertook a huge task when it attempted to establish by legal proof that the sewage of Chicago, highly diluted with water from Lake Michigan, and after a flow of 357 miles through the drainage canal, the Des Plaines, Illinois and Mississippi rivers, contributes a distinguishable element of pollution to the water supply of St. Louis. Inasmuch as we give the complete text of the decision of the U. S. Supreme Court elsewhere in this issue, and since it is both short and interesting, it is unnecessary to review the decision here. We may, however, call attention to the fact that, in the opinion of the Court, the case for Missouri was "weakened in principle" and the allegation of pollution by Chicago rendered more difficult of proof by the fact that Missouri was itself polluting, or allowing its municipal creatures to pollute, the water supply of St. Louis. As to the significance of the decision, outside of the single case to which it applies, it appears to be of less importance than was generally expected. The only legal principle of general application established seems to be the jurisdiction of the U. S. Courts over the pollution of interstate streams. But, while the decision seems so barren of universal legal principles, the case as a whole is one of the most remarkable on record, particularly in the extent and high quality of the expert testimony produced. Included in this testimony were the results of some unique experiments on the longevity of typhoid and related or comparable germs in water. The acceptance by the U. S. Supreme Court of such testimony on the relation between polluted water supplies and typhoid fever is one of the most notable features of the case.

A type of curved bottoms for steel water tanks and gas-holders which we believe is little known in this country is discussed by Mr. Mullenhoff elsewhere in this issue in an article on "European Gas-Holder Design." This form of bottom was devised by the late Professor Intze, of Aachen, Germany, and consists "of several conical or spherical surfaces, arranged in such a way that there is no, or only a very small, compressive or tensile stress in the rings supporting it."

A mathematical analysis of the Intze tank bottom, illustrated by diagrams, is quoted in the article named. So far as we are aware, no such bottoms have ever been used in this country, but, as our readers know, curved bottoms of simple, rather than compound, section, comprising both conical and spherical shapes, were introduced some years ago and are now extensively used.

Two principles of possible far-reaching significance are set out by the New York State Gas Commission in support of its recent order for 80-ct. gas in New York City. The first of these is that the gas companies are entitled to a reasonable return, only, "upon the value of the property actually employed in the gas-making business," and the second is that franchise values should not be included in the valuation named. In other words, not only is watered stock excluded from consideration, but the value of franchises as well. It is assumed, however, that the franchises involved in the case of the New York companies were the virtual gift of the public. The fact that under the franchise law of the State of New York a heavy valuation is placed on these franchises is held by the commission to be of no force, since the tax imposed on these franchise valuations is "charged against the public as an expense of operation, and in reality is paid by the consumer, not by the company." It is interesting to note in this connection that in the schedule for a comparative summary of receipts and expenses under municipal and private ownership, submitted at the recent Washington conference on municipal accounts (see p. 215, Engineering News, Feb. 22, 1906), "taxes and franchise payments" are entered as one of the "charges on account of revenue." The schedule named was prepared by Mr. Harvey S. Chase, M. Am. Soc. M. E., a public accountant of Boston, Mass., for use in the municipal ownership investigation now being conducted by the National Civic Federation. Mr. Chase, it may be added, was formerly superintendent of a private gas and water company, and has made a number of investigations of municipal undertakings that resulted in reports unfavorable thereto, so for these and other reasons he cannot be considered, to say the least, a partisan for the municipal side of public questions. We believe that the adoption by the New York Gas Commission of the principles outlined above may prove to be a most important step in the establishment of just relations between public service corporations and the public, and that eventually the corporations may come to the same conclusion.

The commotion in municipal political circles that would be occasioned in the average American city or town by advertising for a city engineer can be better imagined than described. This and many other municipal positions are filled by such means as a matter of routine in Great Britain and we notice that two Canadian cities have just been advertising for engineers: Regina for a city engineer and surveyor at a salary of $2,000 a year; and Portage la Prairie for a resident engineer, salary not stated. The practice might well be adopted in this country, particularly in many of our smaller cities and towns, where it frequently happens that no local man can be found at all fitted for an engineering or other position requiring technical knowledge.

THE ADOPTED PLAN FOR THE PANAMA CANAL.

After careful study of the majority and minority reports of the Board of Consulting Engineers for the Panama Canal, we are satisfied that the lock canal project recommended by the minority of the Board is far superior to the sea-level project, and that the action of the Canal Commission and of Secretary Taft and President Roosevelt in adopting the lock canal project ought to receive the hearty approval of the engineering profession.

Doubtless there will still be those who will hold to the sea-level canal idea; but the great majority of the profession who give intelligent study to the problem, will, we feel sure, be well satisfied that the lock-canal project now presented is much to be preferred to the sea-level plan.

It is worth noting that the very members of the Consulting Board who voted for the sea-level canal put themselves on record to the effect that the lock canal proposed was a satisfactory means of transit* and admitted that if they were reporting on a canal to be built by a corporation as a business enterprise, they would unhesitatingly favor a lock canal. They voted for a sea-level canal instead, because it was to be built by a great and wealthy government, and one member even went so far as to say:

"The additional cost of the sea-level canal . . . is a matter of no consequence to the Government, provided the expenditures are made honestly and provided there is a return for the money so expended."

Perhaps what was meant was an *adequate* return for the money; but we cannot but feel that the general idea that the United States treasury is equal to any and all demands was a controlling idea in the minds of the sea-level canal advocates.

It is with this position that we would take issue. While the Government can afford to build with far greater permanence and ampler provision for the needs of the future than any private corporation, it ought not to spend a hundred million dollars additional at Panama for a sea-level canal instead of a lock canal unless the completed channel would really and actually be worth that hundred million dollars more than the lock canal when completed.

Now no one, not even the sea-level advocates, will seriously claim that a lock canal is not a thoroughly satisfactory means for navigation. A canal lock is not exactly a new invention, since it dates back, if memory rightly serves, to Leonardo da Vinci (1452-1519). The locks at Panama will be, it is true, larger than any others ever built, yet they will be not much larger after all than the Poe lock at the Sault. That lock is 800 ft. long, 100 ft. wide and 22 ft. deep over the miter sills. The locks at Panama are to be 900 ft. long, 95 ft. wide, with a depth of 40 ft. over the miter sills and a lift of 30 ft. as a maximum.

The Poe lock at the Sault has been in use for ten years and during that time has handled a volume of traffic in excess of the total traffic through all the four great ship canals of Europe. Further the great ore carriers that now regularly pass through the Poe locks are much larger than the average ocean cargo steamers, and it cannot be shown that the existence of this lock has in any way hindered the growth in the size of vessels on the Great Lakes. In other words, the theory of the sea-level advocates to the effect that while a lock canal is all right for moderate size vessels it is a grave danger to the largest class of vessels, is thoroughly disproved by the size of the vessels which are regularly using the lock at the Sault.

President Roosevelt in his letter which we published last week, points out that the sea-level canal advocates have apparently failed to properly value the experience at the Sault canal, and his position is well taken. The opinions of all men—even engineering experts of the highest rank—are greatly influenced by their own personal experience and observation. Had all the distinguished engineers on the Consulting Board been as familiar with the Sault canal as are Mr. Ripley or Mr. Noble, we are strongly inclined to believe that if any votes for the sea-level canal had been recorded, they would have been in the minority.

We have laid stress on this feature of the locks because it is practically the sole ground on which the sea-level party based its claims. The burden of proof was on the sea-level advocates to show that it is worth while to spend from a hundred to a hundred and twenty-five million dollars more money and three to twelve years more time to have at the end a sea-level canal instead of a lock canal. The sole argument offered, is the argument that the locks will be an obstruction to navigation, and that under certain possible contingencies, accident or disaster of some sort may result through the presence of the locks. If these arguments seem weighty and worthy of acceptance to any of our readers, we urge them to carefully study the report of Messrs. Noble,

*"It is not suggested that a maritime canal with locks forming the essential feature is an inherently unsafe system of navigation for experience has not only demonstrated the contrary, but the matter is one of degree. A navigation with locks of small size capable of passing the ordinary commercial steamers may be made reasonably safe." Majority Report of Board of Consulting Engineers, p. 61.

Abbot, Stearns, Ripley and Randolph, presented in this issue. These engineers prove, by the results of actual experience, that disasters to ships in passing through locks are so rare as to be practically unknown. As a matter of fact, a vessel is in no more danger in passing through a canal lock than she is in passing into a dock chamber or coming alongside a pier, which she must do at the end of every voyage. The real danger to vessels in a canal is from running aground in passing through narrow and crooked channels. This has frequently happened in the channels on the Great Lakes and in the sea-level Suez Canal. It is all the time occurring in the channels at harbor entrances all over the world, and it is as certain as anything can be that if a sea-level canal were made at Panama—a narrow, winding ditch nearly 50 miles in length, as it would have to be—that vessels passing through would run aground more or less frequently, with consequent delay and possible obstruction to traffic.

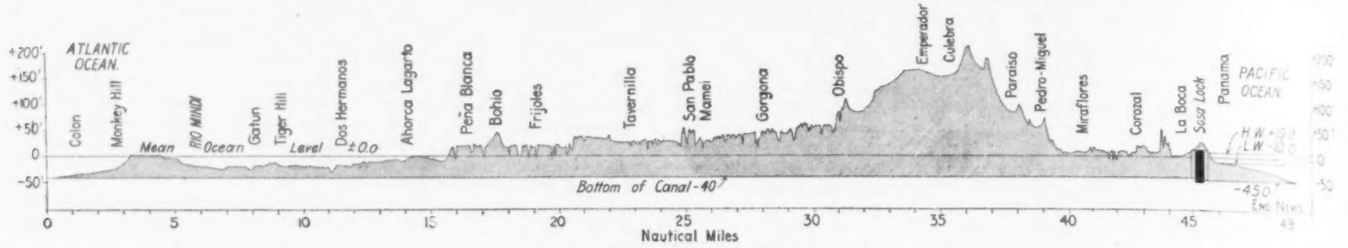
We fail to see, therefore, wherein a sea-level canal would as an actual practical fact furnish better and safer accommodation for the world's commerce than the lock canal now adopted.

It may be objected that we have omitted in the above all mention of the Gatun dam as an element in the lock canal plan to be criticised; but we cannot think that the attempted criticisms of the Gatun dam by the sea-level advocates will find any serious support among American engineers practically familiar with earth dam construction. The Gatun dam is no higher than other earth dams that have been standing for a generation. Its design is chiefly notable for the great surplus height and width that have been adopted, not from necessity, but to make the safety of the structure absolutely without question. In regard to the existence of permeable water-bearing strata at a depth of over 200 ft. under a part of the dam, we invite attention to the very full and fair discussion of this subject in the minority report, which deserves the careful study of every engineer interested in dam construction. Here we may only take space to say that the sea level advocates apparently think it possible that the waters of Lake Gatun might find a passage through this deep permeable stratum and escape, with possible undermining of the dam.

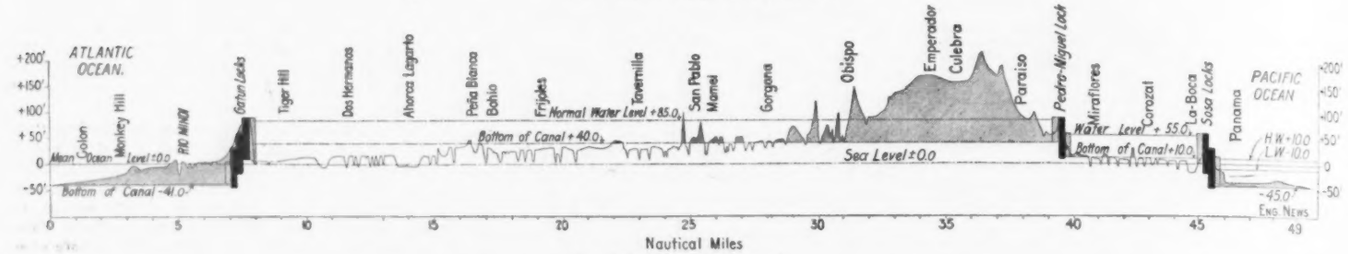
If any such disaster has ever befallen a great earth dam in all engineering history, we are not informed of it. A narrow earth embankment may fail by percolation and undermining, but water cannot pass beneath an artificial hill half a mile wide at the base in any quantity sufficient to be of any practical moment. Experience has shown, too, that every artificial lake formed by damming a stream, rapidly has its bottom covered with a layer of fine silt and mud brought in by the tributary streams, which soon makes the basin water-tight, even where slight leakage takes place at first.

The most convincing contrast between the magnitude of the task presented by the sea-level canal and that which the lock canal involves is the comparative profiles of the two, which we reproduce herewith from our last issue. For a sea-level canal you must dig a deep and broad ditch all the way from ocean to ocean, its bottom 40 ft. below sea level all the way, and much of the material involving rock excavation under water. For the lock canal the excavation is trifling everywhere, save through the Culebra cut, and here the volume to be taken out is reduced more than half. The comparative cross-sections of the Culebra divide at the highest point shown herewith well illustrate this.

It seems to us that the reduction in the size of the job to be tackled at Culebra is a very important matter. Of course, steam shovels can dig through that great mass of rock in time, and cars can in time haul away and dispose of this material; but to keep steam shovels enough working on that whole stretch of eight or ten miles, to keep them all supplied with cars and to handle and discharge these loaded cars, is a transporta-



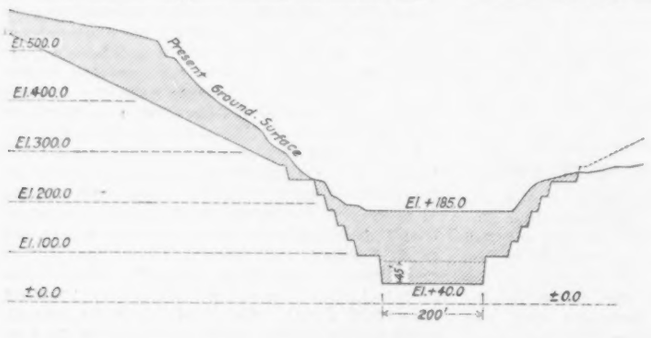
A. Profile of Sea-Level Canal.



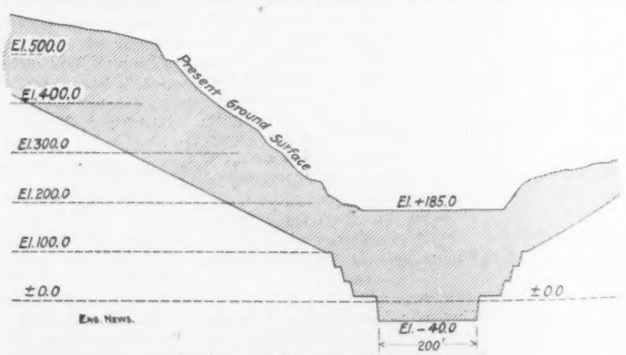
B. Profile of Lock Canal.

COMPARATIVE PROFILES OF SEA-LEVEL CANAL AND 85-FT. SUMMIT LEVEL LOCK CANAL.
(Shaded Area in Each Profile Shows Material To Be Excavated.)

tion problem nothing short of stupendous. Just how it is going to be done is not yet determined. We print on another page of this issue a plan for doing this work which was developed by Mr. John F. Wallace while Chief Engineer of the work. Those of our readers who study Mr. Wallace's plans will note that they relate only to the single section of the Culebra cut, one mile in length, where the cutting is heaviest. But simultaneously with this, work must proceed on each and every other mile of the great divide cut, eight miles in length, and provision must be made that the movement of empty and loaded trains to and from these several sections shall not interfere with each other. This is a transportation problem wholly unprecedented, and upon its solution the rate of progress and time of completion of the sea-level canal would primarily depend. In every other great canal excavation, such as the Chicago Drainage Canal or the Manchester Canal, the material excavated has been disposed of along the banks of the channel, so that the work on one section was wholly independent of the work on another section. At Culebra, however, the



Lock Canal.



Sea-Level Canal.

COMPARATIVE CROSS-SECTIONS OF DEEPEST PART OF CULEBRA CUT FOR A SEA-LEVEL CANAL AND FOR THE LOCK CANAL.

great width and depth of the excavation and the topography on each side compel the transportation of practically all the material to disposal grounds beyond each end of the cut.

It is because of this that it will be impossible probably to divide up the Culebra cut into sections and have the work done by contract, for the contractors on the inner sections would have

to haul all their material out over the sections on which other contractors were at work, and the resulting disputes, confusion and litigation would be certain to tie up or retard the work. On the other hand, it is doubtless impossible to let the whole Culebra cut by contract and get real competition for the work. The risks involved are too great, and the size of the work is too vast, for contracting firms to submit bona-fide competitive bids. Apparently, therefore, this part of the work at Panama at least must be done directly by the Government.

For all these reasons we hold that the reduction from 110,000,000 cu. yds. in the Culebra cut for the sea-level canal to 53,800,000 cu. yds. for the lock canal is a reduction of immense importance, not only because of its effect on the cost, but on the time required for the work.

In considering the relative cost of the rival projects, it is noteworthy that no account has been taken of the interest on the money expended during construction. It is said that this is unnecessary, because the work is to be done by the Government and the money will be raised by taxation; but we must confess ourselves unable to support this point of view. The Panama Canal is a business enterprise, and we hold that when a Government—national, state or municipal—undertakes a business enterprise, the only safe way to proceed is on business principles. As a matter of actual fact, the canal will doubtless be built with money borrowed on Government bonds, and the Government must pay interest on a gradually increasing investment until the canal is completed and traffic returns begin to come in to relieve the taxpayers of the burden. The interest on these bonds is as legitimate and necessary a part of the cost of construction as the purchase of steam shovels or the salaries of engineers. If we assume an interest rate of only 2%, relative costs for the sea level project and the lock project as assumed by the Canal Commission of $272,000,000, and $140,000,000 and the relative times for construction as 18 years and 9 years, then the interest charge at completion for the two projects will increase the actual total costs by over $100,000,000 for the sea-level canal and by about $26,000,000 for the lock canal. Since this interest charge must actually be paid by the Government, year by year, while the canal is under construction, it ought manifestly to be considered, in comparing the total cost of the two projects, and the comparison then is between a total cost of some $372,000,000 for the sea-level canal and $166,000,000 for the lock canal.

Thus, in the light of cold facts and figures, the sea-level advocates were advising the nation to spend over $200,000,000 for the sentimental advantage which a sea-level canal possesses over a lock canal!

That it does possess a sort of sentimental advantage we shall freely admit, and it was this which struck, so to speak, a popular chord when Messrs. Wallace, and Burr and Parsons, of the old Commission, first came out in favor of a sea-level canal a year ago. At the time it seemed not at all improbable that this popular sentiment expressed in the newspaper press might carry the plan to the point of official adoption, but the change in the personnel of the Commission and the appointment of the Consulting Board put a new complexion on affairs and forced a serious comparison of the two plans of something more than a superficial order. Through the failure of the members of the Consulting Board to agree, this comparison has been made public, and the engineering profession can form its own judgment as to the relative merits of the two and the strength of the respective arguments.

In our opinion it speaks volumes for the wisdom and statesmanship of President Roosevelt and Secretary Taft that they had the discernment to appreciate the force of the argument made by the able American hydraulic engineers who were members of the Board and the comparative weakness of the argument for the sea-level canal. They have safely piloted the nation through a most difficult and dangerous crisis; and we venture to predict that future historians will rank the action of the President on the Panama Canal plan as one of the most able and statesmanlike acts of his administration.

LETTERS TO THE EDITOR

Another Civil Service Paper in "Arithmetic."

Sir: I enclose an examination paper on arithmetic which may be of interest as a comparison with the one I sent you a few days ago. G. S. W.

New York, N. Y., Feb. 20, 1906.

TRANSITMAN AND COMPUTER.

[Feb. 16, 1906.]

ARITHMETIC.

1. (a) Find the area of a triangle of which two sides are 297 ft. and 242.2 ft. and the included angle is 60°.
(b) The diagonal of a trapezium is 549 ft. and the perpendicular distances from the vertices are 297 ft. and 214.5 ft. Find the area.
(c) Given the three sides of a triangle, 24 ft., 36 ft., 48 ft. Find the area.
2. In a triangle, the angle B is 50° 30′, the angle C is 122° 9′, and the length of the side CB is nine miles. Find the lengths of the unknown sides.
3. Find the area of the segment of a circle whose diameter is 50 ft., the chord is 40 ft., and the versed sine is 10.
4. Given the radius, 30 ft., and the chord 44 ft. Find the center angle and the circumference.

[NOTE.—No tables or the slide rule allowed.]
Time allowed, two hours.

Civil Service Examinations for Municipal Engineering Positions in New York City.

Sir: Permit me to say a word in reference to the letter of G. S. W. on New York City Civil Service Examinations printed in your issue of Feb. 22. The writer was for two years one of the Engineer Examiners for the New York City Civil Service Commission. As a result of a conscientious effort to better conditions by making examinations short, practical and above suspicion, he became persona non grata.

The powers that be prefer examiners more sympathetic and "loyal" to themselves. Accordingly, examiners are not selected now by the Civil Service method of open public examination, but are appointed by those in control. *The examiners are not examined.* Of course, examiners who have not been "through the mill" themselves cannot be expected to realize that a dose of ten arithmetic questions like those submitted take time to answer on paper. Nor can such examiners be expected to realize that a candidate who is proficient in such arithmetic is probably just the kind of person that is not and cannot be made into a "live," satisfactory assistant engineer.

What can be done about it? Two years' endeavor as an examiner convinces me that the Civil Service or Merit idea is very much undeveloped in practice. Those who preach loudest of its beauties are ignorant of its actual operation, and are least willing to make sacrifices to improve conditions. Nothing can be done about it, except to advise well-intentioned young men not to humiliate themselves or lose their time with Civil Service examinations, until some of the preaching is put into practice and there is an even chance that they will meet in the actual examinations some of the fairmindedness and justice of which we hear so much.

David H. Ray, A. M., C. E., Assoc. Am. Soc. M. E.,
N. Y. C. Civil Service Examiner, 1903-1905.

New York, N. Y., Feb. 23, 1906.

A Straight-Line Instrument for Trisecting an Angle.

Sir: You had an interesting little paragraph under this heading on page 16 of your issue of Jan. 4, and I beg you to allow one of your readers to make the following comments on the same.

The discovery that "H E = 2 A B" cannot lay claim to originality. Exactly in accordance with the above-mentioned equality, I have likewise constructed an instrument five years ago which eventually took the form schematically represented in Fig. 1 herewith. The manipulation may be seen of itself from the sketches. The proof of the construction may likewise be read off direct from the instrument. The three arms a_1, a_2, a_3 are of equal length, the consequence being that

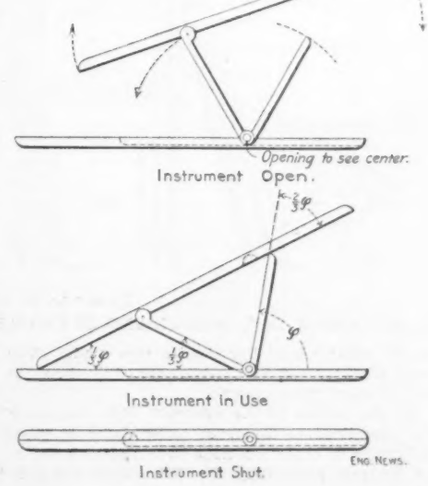


Fig. 1.

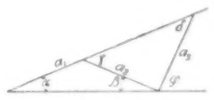


Fig. 2.

$$\angle\ \alpha = \beta$$
$$\angle\ \gamma = \delta$$

and moreover

$$\angle\ \gamma = \alpha + \beta\ (= 2\,\alpha = \delta)$$
$$\angle\ \phi = \alpha + \delta = 3\,\alpha$$

or the opposite

$$\alpha = \beta = \frac{\phi}{3}$$

The equality H E = 2 A B is not apparent in this instrument. However, by drawing the straight line n it may be recognized at once, and by means of the complete diagram, Fig. 3, it may be proved considerably clearer and simpler than has been the case in your previous article:

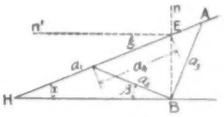


Fig. 3.

$$\angle\ \xi = \alpha = \beta$$

therefore

$$a_4 = a_2\ (= a_1 = a_3)$$
$$a_1 + a_4 = 2\,a_3$$

or

$$H\,E = 2\,A\,B.$$

The advantage of this little instrument over the one mentioned on page 16 which may especially be noted is:

(1) No preliminary auxiliary construction is necessary, and

(2) It works considerably easier, as there is only one point to glide instead of two, this also not taking place in a forced manner.

Yours respectfully,
Otto Fröhlich, Engineer,
Gutehoffnungshütte, Bridge Construction Section.
Sterkrade b/ Oberhausen, Germany, Jan. 25, 1906.

CONSTRUCTION WORK ON THE CHARLES RIVER DAM AND BASIN AT BOSTON, MASS.

By J. Albert Holmes.*

The act authorizing the construction of a dam across the Charles River provided that the Boston & Maine Railroad should remove that portion of its freight bridge southerly and westerly of a line 400 ft. from the downstream face of the proposed dam at the Cambridge shore and about 360 ft. opposite the lock near the Boston shore.†

A careful study of the problem of how to care for the traffic passing over Craigie Bridge during the construction of the dam led to the following solution: Compliance on the part of the railroad with the above-mentioned act left nearly the whole of the freight bridge available for reconstruction into a highway bridge. The necessary legislation was obtained and an agreement entered into with the railroad company whereby the additions and changes required in the bridge to adapt it to highway purposes and the removal of the same upon the completion of the dam should be performed by the commission.

The above work called for an addition to the width of the freight bridge at the Boston shore of 48 ft., which is the full width of the temporary bridge; changing the direction of the draw channel to bring it in line with the lock; building a guide pier, part of which is permanent; constructing fenders and a draw; installing the necessary machinery, and building short approaches through the railroad company's property in both Cambridge and Boston.

The draw consists of four leaves, operated in pairs, lifted by two 25-HP. motors.

The railroad company began the construction of its new four-track freight bridge on Oct. 25, 1904. On March 26, 1905, trains were operated over the southerly half for the first time. The contractor for the dam and lock, Holbrook, Cabot & Rollins Corporation, began on March 2, 1905, to drive piles for the new portion of the bridge at the Boston end.

As soon as the railroad company removed its trains from the old bridge the work of driving additional piles and otherwise strengthening the bridge west of the draw was begun. Some 500

*Assistant Engineer, Charles River Basin Commission, 12 Bridge St., East Cambridge, Mass.

[†Previous articles on this dam and basin appeared in our issues of Oct. 6, 1904, and Jan. 12, 1905. Both articles were by Mr. Holmes. The purpose of the dam is to form a fresh water pleasure basin, which will be bordered by parks and driveways; also to prevent the exposure of unsightly and unhealthy mud flats, at times of low tides, in the present tidal reaches of the river.—Ed.]

spruce, Norway pine and oak piles of a maximum length of 69 ft. were driven in the guide piers, fenders and the bridge itself, using floating and track pile-driving machines. The new roadway was laid directly on the ties of the old bridge, which were mostly 6 × 8-in. yellow pine, laid 2 to 5 ins. apart.

porary bracing was left in place. Elevations given in the text and shown on the sections and plans refer to a datum about 100.64 ft. below mean low water of the sea.

The quantities of square timber per linear foot called for by the plans were 6-in. yellow pine grooved sheeting 38 ft. long, 456 ft. B. M.; wales,

stituted in place of a dam 30 ft. between [illegible] faces of sheeting the one already described, [illegible] is 8 ft. between sheeting, and changed its [illegible] slightly in relation to the fill. Mr. Frederic [illegible] Fay, M. A. Soc. C. E., of Boston, Mass., was [illegible] sulting engineer for the contractors in the de[illegible] of the coffer dam.

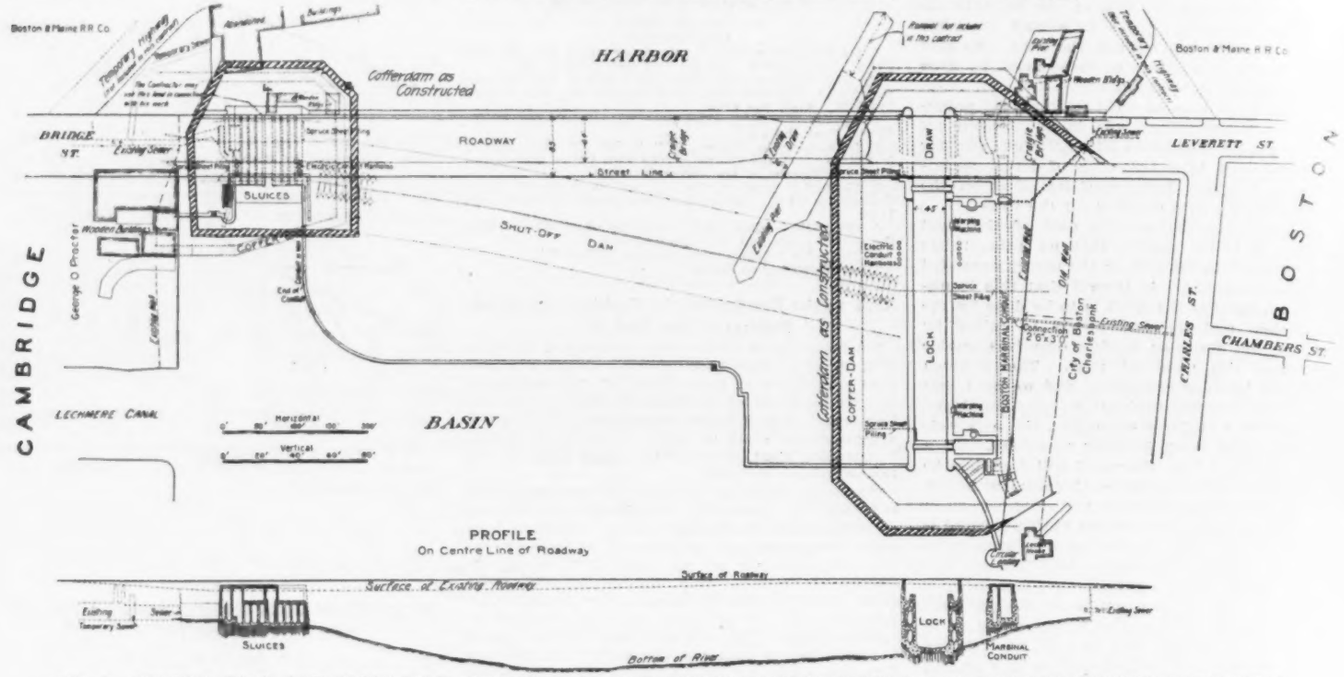


FIG. 1. GENERAL PLAN AND PROFILE OF CHARLES RIVER DAM, SHOWING COFFER DAMS AS BUILT AND AS ORIGINALLY PROPOSED.
(The dotted lines indicate the coffer dams as originally proposed.)

The bridge was opened to travel July 2, 1905, and the old Craigie Bridge closed at the same time. [The last-named bridge, as may be seen in Fig. 1, was on the site chosen for the dam.—Ed.]

THE COFFER DAMS.

On July 5 the contractor began removing the old Craigie Bridge to make room for the construction of the Boston coffer dam (Fig. 1), pile-driving for which had begun on March 9, 1905. Closure was made Sept. 29, 1905. The coffer dam is 625 ft. long between the inner rows of sheeting, 255 ft. wide at a point midway of its length, and has an area of 3.8 acres inside its outer row of sheeting. It has but three sides, the Charlesbank sea wall forming the fourth, or east, side. The

struts and fillers, 107 ft. B. M.; spruce, including splines, 31 ft. B. M. Of bolts and washers there were used 24¼ lbs. of 1¼ in. diameter and 12 lbs. of short ¾ and 1-in. diameter. A total of 437 spruce piles of an average length of 45 ft. were driven, and about 740 M. ft. B. M. spruce and yellow pine were used in the construction of the dam and shore connections. The price bid for the coffer dam, which included maintenance and removal of certain portions, was $70,000.

At the south end of the dam are two sluice-gates of a combined cross-sectional area of 36 sq. ft., their bottoms being at the elevation of low water. These gates were left open until sufficient material had been placed against the dam

The specifications called for spruce, oak or Norway pine piles, 11 ins. in diameter and up at the butt and 6 ins. in diameter and up at the tip, exclusive of bark; yellow pine timber to be "Square-edged Inspection"; each line of wales to be bolted to guide piles by one ¾-in. bolt at each pile; sheeting to be yellow pine, with spruce splines.

No serious difficulties were encountered in the construction of the dam. The depth at low water ranged from nothing at the sea walls to 20 ft. at the northwest corner. The sheeting was driven to hard bottom, or given at least 15 ft. penetration.

The success of the dam and the care with which

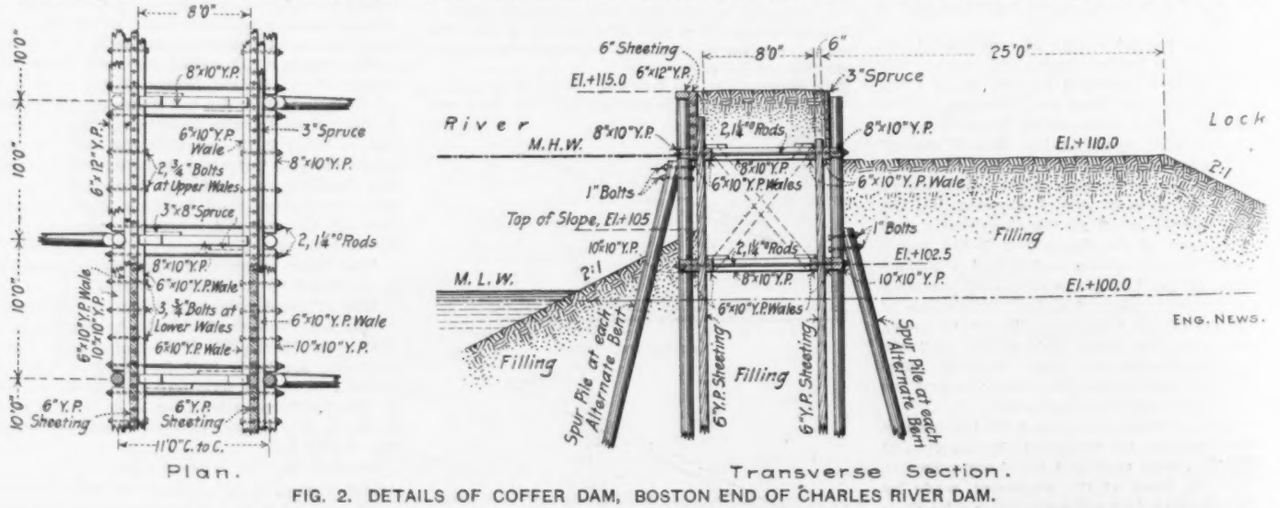


FIG. 2. DETAILS OF COFFER DAM, BOSTON END OF CHARLES RIVER DAM.

length of dam composed of double rows of piles and sheeting is 1,190 ft. from wall to wall, with suitable cut-offs in addition extending back of the wall at each end.

Reference to the plan and section of the coffer dam, Fig. 2, and to the view, Fig. 3, will show the details of construction. The diagonal tem-

at the point where the closure was made. The gates are provided for the purpose of flooding the dam in case of necessity.

By the terms of the contract, the contractor was permitted to construct coffer dams of other designs or in other locations than those shown in the contract plans (Fig. 1). The contractor sub-

it was constructed is shown by the small leakage, which amounted to about 400 gallons per minute when the water inside had been pumped down to 10 ft. below low water in the river. The rise of the tide, which amounts to nearly 10 ft., does not seem to affect the leakage.

The filling between the sheeting of the coffer

dam is composed of clay, silt and sand. The bottom of the fill inside the dam is clay and sand and the upper part gravel. The fill outside is clay and gravel.

Within the coffer dam is to be constructed the lock, a portion of the Boston marginal conduit, gate chamber and other structures. The bottom

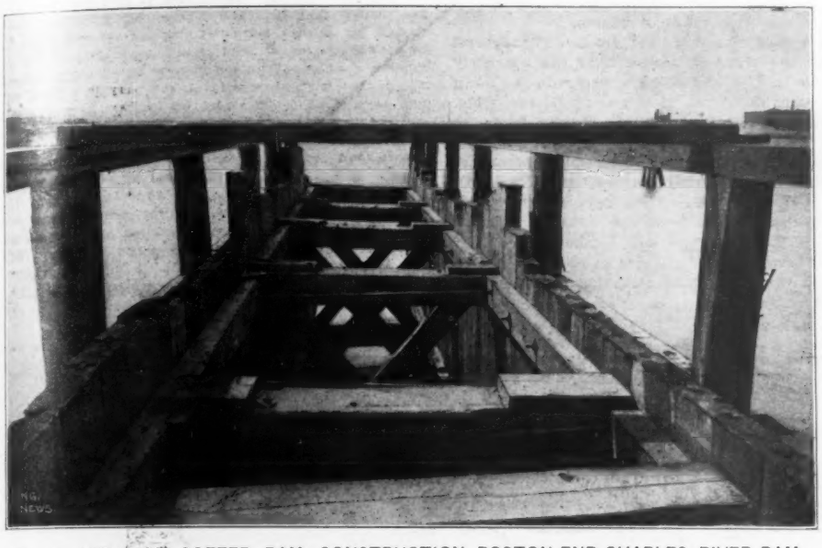


FIG. 3. VIEW OF COFFER DAM CONSTRUCTION, BOSTON END CHARLES RIVER DAM.

of the concrete under the lock will be 27.5 ft. below mean low water. This required the dredging of 32,900 cu. yds. of material, some of which was placed in the fill for the main dam, the larger part being placed in the coffer dam fill.

Dredging under the lock began April 27, 1905. Filling at the coffer dam began May 22. The dredging under the lock and gate recesses was completed before the coffer dam was closed. It was found necessary to dredge some soft material below the grade of the concrete at the north end of the lock and refill with gravel. The contract provided that the piles under the structures to be built in this coffer dam be driven after the dam was pumped out, but the contractor was allowed to drive about 500 piles at the north end of the lock under the toe of the coffer dam fill at a point where the fill was deep and the river bottom soft. These piles were driven in from 20 to 30 ft. of water from a floating pile-driver, using extension gins and a follower. The tip of the pile was held in the gins by means of dogs (see Fig. 4) attached to the inner sides of the extension gins, near their lower ends, opposite and opposed to each other. The dogs are driven into the pile from above, giving them an upward slant. The gins were lowered until the pile touched the bottom, and the driving forced the dogs further into the piles, then downward, finally allowing them to drop out. This device for holding the piles in the gins is patented by Mr. James W. Rollins, Jr., M. Am. Soc. C. E. The top of the pile was held in a cup-shaped casting on the lower end of the follower. A total of 514 piles were driven in this manner between Aug. 8 and 15, 1905.

An aggregate of 117,500 cu. yds. of material were placed in the fill of the coffer dam, some of it coming from the excavation for the lock, but the greater part from points in Boston Harbor, where dredging was going on, and from gravel banks in the river above the new Cambridge Bridge.

The sluice gates were closed at 3 a. m., Oct. 11. The elevation of the water inside the coffer dam at that time was about 102.0. At 1 p. m., Oct. 12, the water stood at elevation 94.1. On Oct. 14, after 31 hours of intermittent pumping, the surface stood at elevation 88.5. Frequent stops were made to allow the fill to settle and for the water to drain out, and also to change the position of the pump float and add short lengths to the vertical outlet pipe. The dam was not entirely pumped out for some time, it being necessary to place a grillage under the pump float and excavate a sump for the suction pipe. The pump used was a 15-in. Lawrence centrifugal, direct connected to a Westinghouse junior engine, the whole mounted on a float, with flexible steam pipe connections from a steam plant placed on a pile foundation at one side of the coffer dam. The 15-in. pump and engine was afterward placed on the coffer dam fill and connected with a sump. Two 6-in. centrifugal pumps, one steam and the other electrically driven, have been added, one of which takes care of the leakage, the other being held in reserve.

Pile-driving with land machines began under the lock Oct. 31 at the north end, and is being carried on at the rate of about 1,000 piles per month.

The coffer dam at the Cambridge end is under construction. It has an area of 1.2 acres, and is being built in the same manner as the Boston coffer dam. The foundation piles under the sluices to be built within the Cambridge coffer dam are being driven from a floating machine similar to the one used in the Boston coffer dam.

BOSTON MARGINAL SEWER.

The great fresh water basin, about eight miles in length, created by the construction of the dam, will be used principally for pleasure boating and its shores occupied by parks and driveways. It is desirable, therefore, that as little sewage as possible be allowed to enter it.

To prevent as far as practicable the entrance of sewage into the basin, the commission is required to construct marginal conduits, one along the Cambridge shore and one along the Boston shore of the basin, to intercept and convey to a point a short distance below the dam the sewage from several large sewers, a portion of which is discharged at present into the river above the site of the dam.

Of the conduit along the Boston shore, known as the Boston marginal conduit, the first section, about 500 ft. in length, will be built within the Boston coffer dam. Section 2, beginning at the coffer dam and extending through the Charlesbank, mostly under the Charles Street Mall, to the southerly side of the approach to the new Cambridge Bridge, a distance of 1,804 ft., together with an overflow chamber and outlet to the river about 175 ft. long, is practically completed.

The contract for this section of the conduit was let to James Driscoll & Son, of Brookline, Mass., June 13, and work begun June 21, 1905.

Previous to the construction of the Charlesbank, the river front was occupied by a number of wharves and docks. The old wharves were retained by sea walls and wooden bulkheads. These had been buried up and the docks filled in the course of constructing the park, much of the material used being cinders and city refuse. The line of the conduit passed through these old sea walls at about the head of the docks. The invert of the conduit is level and the surface of the ground was nearly parallel with the invert, making an almost uniform cut of 20 ft., the width of trench being 10 ft. Most of the excavation and backfill was made with a Carson-Lidgerwood cable machine, 300 ft. between towers. Portable stiff-legged derricks were also used, and at the overflow chamber a bull-wheel derrick having a 65-ft. boom and a 72-ft. mast was employed.

The trench was braced throughout, two sets of spruce sheeting being used; the upper set, 12 to 15 ft. long, of 2-in. rough planks; the lower set, abuut 8 ft. long, of 2-in. rought planks, and, where necessary to shut out the tide, 3-in. grooved and splined planks. The lower set of sheeting was used for the back of the concrete forms for the side walls, and was left in place. The rangers and braces used were 6 × 8-in. stuff. In good material, the trench was excavated to the depth and form of the bottom of the masonry. Soft material was removed to a depth of from 4 ins. to 4 ft. and replaced with gravel. No piles were required for a length of 422 ft. at the northerly end, the bottom of the excavation being in hard material, 60 ft. of this being through shaley ledge. The remaining 1,382 ft. of conduit required a pile foundation. The piles are spaced 2 ft. c. to c. under the side walls and 4 ft. c. to c. under the invert. Spruce piles, ranging from 17 to 38 ft. long, butt not less than 10 ins. in diameter and tip not less than 6 ins. in diameter, were used. The pile-driving was carried on mostly during the night, to avoid interference with the use of the cableway. A pile-driver having low main gins and especially fitted with extension gins and a 9-ft. hammer weighing 2,100 lbs. was used. This machine was capable of driving piles to the bottom of the 20-ft. trench without the aid of a follower, and also in very contracted spaces. The piles were required to sustain a load of five tons each. In the Engineering News formula this is equivalent to a penetration of 3 ins. under the last blow, with a fall of 10 ft.

The piles under an old sea wall which came in the line of the conduit were utilized for a distance of 100 ft., 243 of these piles being made use of. In addition, 1,813 piles, having a total

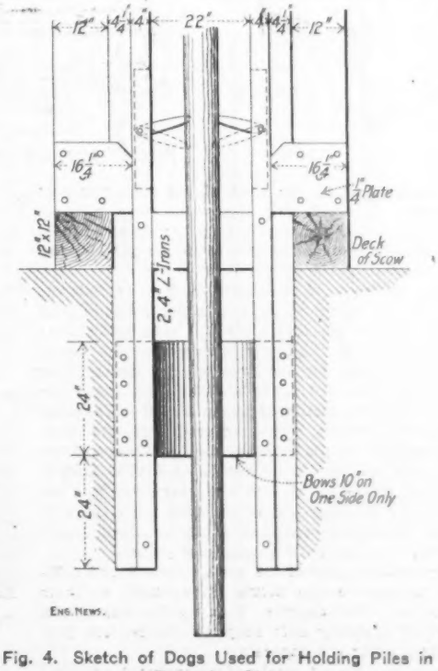


Fig. 4. Sketch of Dogs Used for Holding Piles in Extension Gins.
(Patented by James E. Rollins, Jr.)

length of 50,532 ft., were driven. The material through which the piles were driven consisted of a silty sand and gravel, stiff clay and compact sand and gravel.

Considerable water found its way into the trench, especially along the old sea walls. The ground water varied from elevation 103 to 108, fluctuating with the tide in the river near by. A

10-in. underdrain conducted the water to sumps about 500 ft. apart, from which it was pumped by a pulsometer and by a 4-in. and a 6-in. centrifugal pump. At times all three pumps were required to keep the trench free from water.

The conduit (see Fig. 5) is 92¼ ins. high by 76 ins. wide. The cross-sectional area of the conduit is 41.34 sq. ft., and the area of the masonry 34.29 sq. ft.

Portland cement concrete was used in the proportion, by volume, of 1 part cement, 2½ sand and 4½ parts broken stone or gravel. At the south end of the section the masonry was flooded at each high tide, the proportions in this part of the work being 1 : 2 : 4. Whitehall, Alpha and Lehigh cements were used.

Concrete was mixed by hand on platforms, and in the case of the invert placed directly in the work. For the side walls and arch it was shoveled a second time from platforms laid on the cross-bracing. At the beginning of the construction a Smith mixer was used and the concrete conveyed in buckets by the cableway, but this method of mixing was abandoned, for the reason that too much of the time of the cableway was occupied in conveying concrete, there not remaining sufficient time to keep the excavation of the trench sufficiently ahead of the pile-driving and masonry.

The sequence of construction was as follows: The invert was first built in short sections, and after setting the forms for the side walls were erected upon it, the lower course of trench sheeting being used for the back of the forms. The walls were carried up to about 4.7 ft. above the invert, and were allowed to set for 36 to 72 hours before the forms were removed and the arch centers put in place. Lagging was carried up with and on top of the arch masonry to hold it in place until set. A 1 to 2 mortar joint was required at the juncture of the arch with the side walls. Masonry in excess of the required cross-sections was paid for at one-half price.

At the beginning of the work it was found difficult to remove the forms on account of their adhesion to the concrete. This trouble was gotten over by applying soft soap to the centers just before placing the concrete.

Ransome twisted steel rods were used as reinforcement, ½-in. and ¾-in. rods being placed in pairs one above the other and the pairs 12 ins. apart, except at the northerly end of the section, where the pairs were 15 ins. apart. Spaces behind the lower rows of sheeting and voids in sea walls were grouted or filled with concrete. To prevent a flow of water along the under side of the masonry from the sides to the underdrain, the lower set of sheeting was driven below the masonry.

After removing the forms the interior of the conduit was found to be fairly smooth. It was pointed and given a wash of neat cement. The invert was plastered with 1 to 1 mortar.

Two overflow sewers were intercepted by this section of the conduit and temporary provision made for conducting the sewage to the river. Upon the completion of the conduit connection will be made with these overflows.

The overflow chamber (see details, Fig. 5) and outlet to the river is located near the southerly end of the section and at right angles to the main conduit, and is 77 ins. in height by 63 ins. wide. This overflow will discharge the surplus from the conduit into the basin in time of heavy storms occurring at high tide. The chamber is so arranged that no floating matter or sludge will escape into the basin. Four openings are provided in the side walls of the conduit, through which the dilute sewage will be discharged into the chamber, where it will rise to the tops of two cast iron troughs set at elevation 108.5, or 0.5 ft. above the proposed elevation of the water in the basin, from which it will be discharged into the overflow conduit and thence to the basin. Stop-plank grooves were provided in the chamber, and just beyond the ends of the cast iron troughs are placed two tide-gates. These gates were built by the Coffin Valve Co. after designs patented by Mr. C. H. Dodd and Mr. Edwin McLaughlin, of Boston.

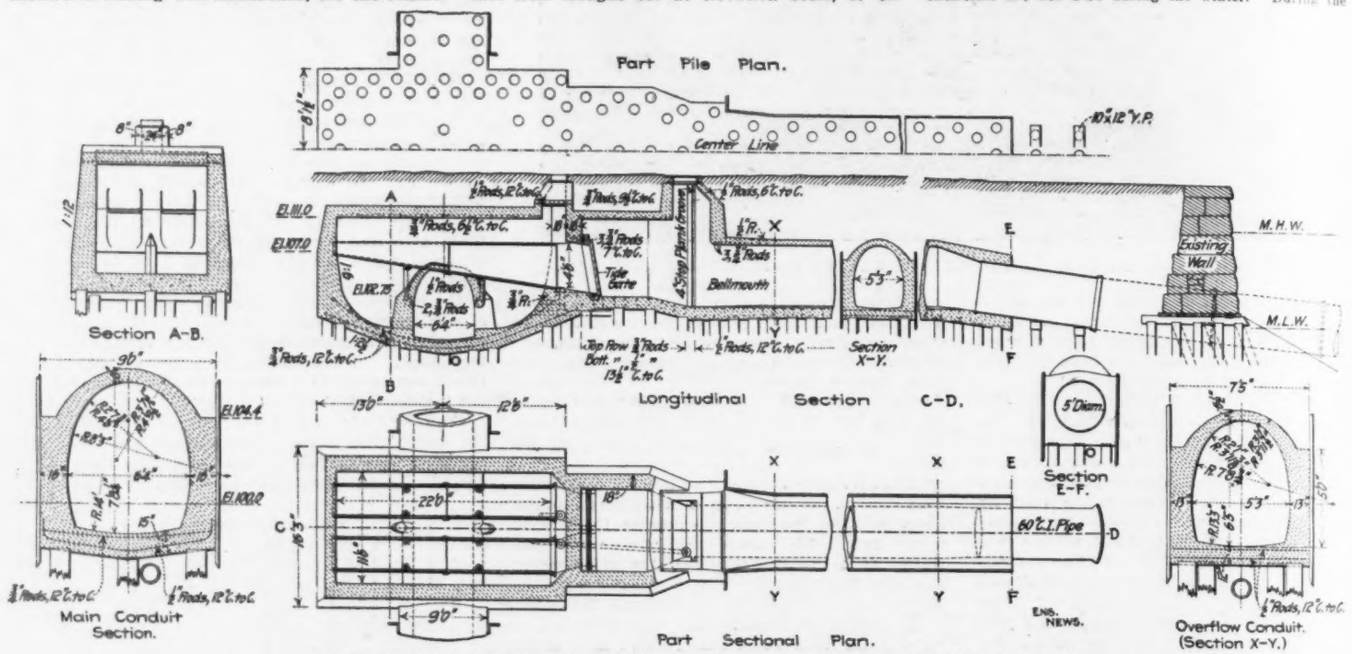


FIG. 5. DETAILS OF BOSTON MARGINAL CONDUIT, SECTION 2, CHARLES RIVER DAM.

The items, estimated quantities and prices bid are as follows:

Items.	Quantities.	Prices bid.
Earth excavation and refill (main conduit)	1,800 lin. ft.	$8.50
Earth excavation and refill (overflow chamber and conduit)	175 lin. ft.	7.00
Rock excavation	200 cu. yds.	5.00
Piles	62,000 lin. ft.	0.14
Underdrain	2,000 lin. ft.	0.75
Concrete masonry (except backing)	2,600 cu. yds.	7.50
Concrete masonry for backing	100 cu. yds.	3.75
Iron and other metal work*	45 tons	8.00
Sheeting left in place	70 M. ft. B. M	18.00
Earth excavation in trench below masonry and underdrain	200 cu. yds.	1.50
Gravel filling in excavation in trench below masonry and underdrain	200 cu. yds.	1.50
Crossings of Fruit St. and Cambridge St. overflows	...	800.00

*All metal work was furnished by the commission. The price given was for hauling, caring for and placing the same.

The Charles River Basin Commission consists of Dr. Henry S. Pritchett, Chairman; Mr. Henry D. Yerxa and Mr. Joshua B. Holden. Mr. Hiram A. Miller, M. Am. Soc. C. E., is chief engineer to the commission, and Mr. Frederic P. Stearns, Pres. Am. Soc. C. E., is consulting engineer. Mr. Frank E. Winsor, M. Am. Soc. C. E., principal assistant engineer, has charge of the designs, and Mr. John L. Howard, M. Am. Soc. C. E., division engineer, has charge of the construction work.

A NOVEL SYSTEM OF SEWAGE TREATMENT at Oberlin, O., has been introduced as a modification of existing practice. In 1894 an area of land was laid out for surface irrigation and intermittent filtration. Although the soil was largely of clay and not well adapted to sewage treatment good results were obtained for a number of years. With the increase in plumbing in the village the land was overtaxed and very little purification secured. The old sludge basins have been covered and the filter beds turned into settling basins. Copperas is introduced at the upper end of one of the branch sewers, and near the lower border of the town lime is added. This plan of treatment was introduced in 1904 and continued in 1905. Between April 14 and Nov. 20, 1905, a total of 151 bbls. of lime was used, at a cost of $155, and somewhat less than a carload of copperas, at a cost of $176. During the same period the labor cost was $100, making a total of $431. It appears that the chemicals are not used during the winter. During the first year the new plan gave fair results and in 1905, with more experience, the results were "quite satisfactory," the farm being "free from odor, and the creek, which almost might be called a dry run, has been in a satisfactory condition." The average amount of sewage during 1905 was 250,000 gallons a day, from the following fixtures: Sinks, 756; water closets, 873; basins, 625; bath tubs, 516; hoppers, 267; set tubs, 80; urinals, 39. There are also 484 cellar drains connected with the sewers, which are on the separate plan. The so-called sewer farm is 20 acres in area. Of this 3½ acres have been underdrained for intermittent filtration; 1¾ acres, not underdrained, has been prepared for filtration. The cost of construction work on the farm to the close of 1905 aggregated $990. The water supply of Oberlin is treated with lime for softening purposes, but the sewage, perhaps due to the entrance of ground water, requires the addition of a small amount of lime to render it sufficiently alkaline for treatment by copperas.

THE STOPPAGE OF STORM WATER SEWER INLETS by pieces of waste wire left on the street by electric light and other linemen was commented on by Mr. W. W. Brigden, of Battle Creek, Mich., at the annual meeting of the Michigan Engineering Society, in January, 1906. Mr. Brigden said:

> In nearly all cities of 10,000 inhabitants and over, the multiplication of wires has become so great as to be a nuisance in itself, and in many cities the stringing and repairing of these wires, especially those of iron, results in innumerable pieces of from 1 in. to 20 ft. being left on the streets to be washed or pushed into sewer inlets and other places for drainage. There is hardly a thing of the same weight or bulk so well calculated to stop up sewer inlets or other similar passages for water, as a turn or two of stiff wire about ⅛-in. diameter. There seems to be no attempt anywhere to do away with this wire nuisance, but there certainly should be. They should be picked up immediately after a piece of work is done and entirely removed from the street.

DECISION OF THE U. S. SUPREME COURT IN THE ST. LOUIS-CHICAGO DRAINAGE CANAL CASE.*

This is a suit brought by the State of Missouri to restrain the discharge of the sewage of Chicago through an artificial channel into the Desplaines River, in the State of Illinois. That river empties into the Illinois River, and the latter empties into the Mississippi at a point about 43 miles above the city of St. Louis. It was alleged in the bill that the result of the threatened discharge would be to send 1,500 tons of poisonous filth daily into the Mississippi, to deposit great quantities of the same upon the part of the bed of the last-named river belonging to the plaintiff, and so to poison the water of that river, upon which various of the plaintiff's cities, towns and inhabitants depended, as to make it unfit for drinking, agricultural or manufacturing purposes. It was alleged that the defendant Sanitary District was acting in pursuance of a statute of the State of Illinois and as an agency of that State. The case is stated at length in 180 U. S. 208, where a demurrer to the bill was overruled. A supplemental bill alleges that since the filing of the original bill the drainage canal has been opened and put into operation and has produced and is producing all the evils which were apprehended when the injunction first was asked. The answers deny the plaintiff's case, allege that the new plan sends the water of the Illinois River into the Mississippi much purer than it was before, that many towns and cities of the plaintiff along the Missouri and Mississippi discharge their sewage into those rivers, and that if there is any trouble the plaintiff must look nearer home for the cause.

The decision upon the demurrer discussed mainly the jurisdiction of the Court, and, as leave to answer was given when the demurrer was overruled, naturally there was no very precise consideration of the principles of law to be applied if the plaintiff should prove its case. That was left to the future with the general intimation that the nuisance must be made out upon determinate and satisfactory evidence, that it must not be doubtful and that the danger must be shown to be real and immediate. The nuisance set forth in the bill was one which would be of international importance—a visible change of a great river from a pure stream into a polluted and poisoned ditch. The only question presented was whether as between the States of the Union this Court was competent to deal with a situation which, if it arose between independent sovereigns, might lead to war. Whatever differences of opinion there might be upon matters of detail, the jurisdiction and authority of this Court to deal with such a case as that is not open to doubt. But the evidence now is in, the actual facts have required for their establishment the most ingenious experiments, and for their interpretation the most subtle speculations, of modern science, and therefore it becomes necessary at the present stage to consider somewhat more nicely than heretofore how the evidence it is to be approached.

The first question to be answered was put in the well-known case of the Wheeling bridge. Pennsylvania vs. Wheeling & Belmont Bridge Co., 13 How. 518. In that case, also, there was a bill brought by a State to restrain a public nuisance, the erection of a bridge alleged to obstruct navigation, and a supplemental bill to abate it after it was erected. The question was put most explicitly by the dissenting judges, but it was accepted by all as fundamental. The Chief Justice observed that if the bridge was a nuisance it was an offense against the sovereignty whose laws had been violated, and he asked what sovereignty that was. 13 How: 561. Daniel, J., 13 How. 569. (See also Kansas vs. Colorado, 185 U. S. 125.) It could not be Virginia, because that State had purported to authorize it by statute. The Chief Justice found no prohibition by the United States. 13 How. 580. No third source of law was suggested by anyone. The majority accepted the Chief Justice's postulate, and found an answer in what Congress had done.

It hardly was disputed that Congress could deal with the matter under its power to regulate commerce. The majority observed that although Congress had not declared in terms that a State should not obstruct the navigation of the Ohio, by bridges, yet it had regulated navigation upon that river in various ways and had sanctioned the compact between Virginia and Kentucky when Kentucky was let into the Union. By that compact the use and navigation of the Ohio, as far as the territory of either State lay thereon, was to be free and common to the citizens of the United States. The compact, by the sanction of Congress, had become a law of the Union. A State law which violated it was unconstitutional. Obstructing the navigation of the river was said to violate it, and it was added that more was not necessary to give a civil remedy for an injury done by the obstruction. 13 How. 565, 566. At a later stage of the case, after Congress had authorized the bridge, it was stated again in so many words that the ground of the former decision was that "the Act of the Legislature of Virginia afforded no authority or jurisdiction. It was in conflict with the Acts of Congress, which were the paramount law." 18 How. 421, 429.

In the case at bar, whether Congress could act or not, there is no suggestion that it has forbidden the action of Illinois. The only ground on which that State's conduct can be called in question is one which must be implied from the words of the Constitution. The Constitution extends the judicial power of the United States to controversies between two or more States and between a State and citizens of another State, and gives this Court original jurisdiction in cases in which a State shall be a party. Therefore, if one State raises a controversy with another, this Court must determine whether there is any principle of law and, if any, what, on which the plaintiff can recover. But the fact that this Court must decide does not mean, of course, that it takes the place of a legislature. Some principles it must have power to declare. For instance, when a dispute arises about boundaries, this Court must determine the line, and in doing so must be governed by rules explicitly or implicitly recognized. Rhode Island vs. Massachusetts, 12 Pet. 657, 737. It must follow and apply those rules, even if legislation of one or both of the States seems to stand in the way. But the words of the Constitution would be a narrow ground upon which to construct and apply to the relations between States the same system of municipal law in all its details which would be applied between individuals. If we suppose a case which did not fall within the power of Congress to regulate, the result of a declaration of rights by this Court would be the establishment of a rule which would be irrevocable by any power except that of this Court to reverse its own decision, an amendment of the Constitution, or possibly an agreement between the States sanctioned by the legislature of the United States.

The difficulties in the way of establishing such a system of law might not be insuperable, but they would be great and new. Take the question of prescription in a case like the present. The reasons on which prescription for a public nuisance is denied or may be granted to an individual as against the sovereign power to which he is subject have no application to an independent State. See 1 Oppenheim, International Law, 293, §§ 242, 243. It would be contradicting a fundamental principle of human nature to allow no effect to the lapse of time, however long. Davis vs. Mills, 194 U. S. 451, 457, yet the fixing of a definite time usually belongs to the Legislature rather than the Courts. The Courts did fix a time in the rule against perpetuities, but the usual course, as in the instances of statutes of limitation, the duration of patents, the age of majority, etc., is to depend upon the lawmaking power.

It is decided that a case such as is made by the bill may be a ground for relief. The purpose of the foregoing observations is not to lay a foundation for departing from that decision, but simply to illustrate the great and serious caution with which it is necessary to approach the question whether a case is proved. It may be imagined that a nuisance might be created by a State upon a navigable river like the Danube, which would amount to a *casus belli* for a State lower down, unless removed. If such a nuisance were created by a State upon the Mississippi the controversy would be resolved by the more peaceful means of a suit in this Court. But it does not follow that every matter which would warrant a resort to equity by one citizen against another in the same jurisdiction equally would warrant an interference by this Court with the action of a State. It hardly can be that we should be warranted in declaring statutes ordaining such action void in every instance where the Circuit Court might intervene in a private suit, upon no other ground than analogy to some selected system of municipal law, and the fact that we have jurisdiction over controversies between States.

The nearest analogy would be found in those cases in which an easement has been declared in favor of land in one State over land in another. But there the right is recognized on the assumption of a concurrence between the two States, the one, so to speak, offering the right, the other permitting it to be accepted. Mannville Co. vs. Worcester, 138 Mass. 89. But when the State itself is concerned and by its legislation expressly repudiates the right set up, an entirely different question is presented.

Before this Court ought to intervene the case should be of serious magnitude, clearly and fully proved, and the principle to be applied should be one which the Court is prepared deliberately to maintain against all considerations on the other side. See Kansas vs. Colorado, 185 U. S. 125.

As to the principle to be laid down the caution necessary is manifest. It is a question of the first magnitude whether the destiny of the great rivers is to be the sewers of the cities along their banks or to be protected against everything which threatens their purity. To decide the whole matter at one blow by an irrevocable fiat would be at least premature. If we are to judge by what the plaintiff itself permits, the discharge of sewage into the Mississippi by cities and towns is to be expected. We believe that the practice of discharging into the river is general along its banks, except where the levees of Louisiana have led to a different course." The argument for the plaintiff asserts it to be proper within certain limits. These are facts to be considered. Even in cases between individuals some consideration is given to the practical course of events. In the black country of England parties would not be expected to stand upon extreme rights. St. Helen's Smelting Co. vs. Tipping, 11 H. L. C. 642. See Boston Ferrule Co. vs. Hills, 159 Mass. 147, 150. Where, as here, the plaintiff has sovereign powers and deliberately permits discharges similar to those of which it complains, it not only offers a standard to which the defendant has the right to appeal, but, as some of those discharges are above the intake of St. Louis, it warrants the defendant in demanding the strictest proof that the plaintiff's own conduct does not produce the result, or at least so conduce to it that courts should not be curious to apportion the blame.

We have studied the plaintiff's statement of the facts in detail and have perused the evidence, but it is unnecessary for the purposes of decision to do more than give the general result in a very simple way. At the outset we cannot but be struck by the consideration that if this suit had been brought fifty years ago it almost necessarily would have failed. There is no pretense that there is a nuisance of the simple kind that was known to the older common law. There is nothing which can be detected by the unassisted senses—no visible increase of filth, no new smell. On the contrary, it is proved that the great volume of pure water from Lake Michigan which is mixed with the sewage at the start has improved the Illinois River in these respects to a noticeable extent. Formerly it was sluggish and ill smelling. Now it is a comparatively clear stream to which edible fish have returned. Its water is drunk by the fishermen, it is said without evil results. The plaintiff's case depends upon an inference of the unseen. It draws the inference from two propositions. First, that typhoid fever has increased considerably since the change and that other explanations have been disproved, and second, that the bacillus of typhoid can and does survive the journey and reach the intake of St. Louis in the Mississippi.

We assume the now prevailing scientific explanation of typhoid fever to be correct. But when we go beyond that assumption everything is involved in doubt. The data upon which an increase in the deaths from typhoid fever in St. Louis is alleged are disputed. The elimination of other causes is denied. The experts differ as to the time and distance within which a stream would purify itself. No case of an epidemic caused by infection at so remote a source is brought forward and the cases which are produced are controverted. The plaintiff obviously must be cautious upon this point, for if this suit should succeed many others would follow, and it not improbably would find itself a defendant to a bill by one or more of the States lower down upon the Mississippi. The distance which the sewage has to travel (357 miles) is not open to debate, but the time of transit to be inferred from experiments with floats is estimated as varying from 8 to 18½ days, with 48 hours more from intake to distribution, and when corrected by observations of bacteria is greatly prolonged by the defendants. The experiments of the defendant's experts lead them to the opinion that a typhoid bacillus could not survive the journey, while those on the other side maintain that it might live and keep its power for 25 days or more, and arrive at St. Louis. Upon the question at issue, whether the new discharge from Chicago hurts St. Louis, there is a categorical contradiction between the experts on the two sides.

The Chicago drainage canal was opened on Jan. 17, 1900. The deaths from typhoid fever in St. Louis, before and after that date, are stated somewhat differently in different places. We give them mainly from the plaintiff's brief: 1890, 140; 1891, 165; 1892, 441; 1893, 215; 1894, 171; 1895, 106; 1896, 106; 1897, 125; 1898, 95; 1899, 131; 1900, 154; 1901, 181; 1902, 216; 1903, 281. It is argued for the defendant that the numbers for the later years have been enlarged by carrying over cases which in earlier years would have been put into a miscellaneous column (intermittent, remittent, typho-malaria, etc. etc.), but we assume that the increase is real. Nevertheless, comparing the last four years with the earlier ones, it is obvious that the ground for a specific inference is very narrow, if we stopped at this point. The plaintiff argues that the increase must be due to Chicago, since there is nothing corresponding to it in the watersheds of the Missouri or Mississippi. On the other hand, the defendant points out that there has been no such enhanced rate of typhoid on the banks of the Illinois as would have been found if the opening of the drainage canal were the true cause.

Both sides agree that the detection of the typhoid bacillus in the water is not to be expected. But the plaintiff relies upon proof that such bacilli are discharged into the Chicago sewage in considerable quantities; that the number of bacilli in the water of the Illinois is much increased, including the bacillus coli communis, which is admitted to be an index of contamination, and that the chemical analyses lead to the same inference. To prove that the typhoid bacillus could make the journey an experiment was tried with the bacillus prodigiosus, which seems to have been unknown, or nearly unknown, in these waters. After preliminary trials, in which these bacilli emptied into the Mississippi near the mouth of the

*Full text of the opinion of the Court, as rendered by Mr. Justice Holmes on Feb. 19, 1906.

Illinois were found near the St. Louis intake and in St. Louis in times varying from three days to a month, 107 barrels of the same, said to contain one thousand million bacilli to the cubic centimeter, were put into the drainage canal near the starting point on Nov. 6, and on Dec. 4 an example was found at the St. Louis intake tower. Four others were found on the three following days, two at the tower and two at the mouth of the Illinois. As this bacillus is asserted to have about the same length of life in sunlight in living waters as the bacillus typhosus, although it is a little more hardy, the experiment is though to prove one element of the plaintiff's case, although the very small number found in many samples of water is thought by the other side to indicate that practically no typhoid germs would get through. It seems to be conceded that the purification of the Illinois by the large dilution from Lake Michigan (nine parts or more in ten) would increase the danger, as it now generally is believed that the bacteria of decay, the saprophytes, which flourish in stagnant pools, destroy the pathogenic germs. Of course, the addition of so much water to the Illinois also increases its speed.

On the other hand, the defendant's evidence shows a reduction in the chemical and bacterial accompaniments of pollution in a given quantity of water, which would be natural in view of the mixture of nine parts to one from Lake Michigan. It affirms that the Illinois is better or no worse at its mouth than it was before, and makes it at least uncertain how much of the present pollution is due to Chicago and how much to sources further down, not complained of in the bill. It contends that if any bacilli should get through they would be scattered and enfeebled and would do no harm. The defendant also sets against the experiment with the bacillus prodigiosus a no less striking experiment with typhoid germs suspended in the Illinois River in permeable sacs. According to this the duration of the life of these germs has been much exaggerated, and in that water would not be more than three or four days. It is suggested, by way of criticism, that the germs may not have been of normal strength, that the conditions were less favorable than if they had floated down in a comparatively unchanging body of water, and that the germs may have escaped, but the experiment raises at least a serious doubt. Further, it hardly is denied that there is no parallelism in detail between the increase and decrease of typhoid fever in Chicago and St. Louis. The defendant's experts maintain that the water of the Missouri is worse than that of the Illinois, while it contributes a much larger proportion to the intake. The evidence is very strong that it is necessary for St. Louis to take preventive measures, by filtration or otherwise, against the dangers of the plaintiff's own creation or from other sources than Illinois. What will protect against one will protect against another. The presence of causes of infection from the plaintiff's action makes the case weaker in principle as well as harder to prove than one in which all came from a single source.

Some stress was laid on the proposition that Chicago is not on the natural watershed of the Mississippi, because of a rise of a few feet between the Desplaines and the Chicago rivers. We perceive no reason for a distinction on this ground. The natural features relied upon are of the smallest. And if under any circumstances they could affect the case, it is enough to say that Illinois brought Chicago into the Mississippi watershed in pursuance not only of its own statutes, but also of the acts of Congress of March 30, 1822, c. 14,, 3 St. 659, and March 2, 1827, c. 51, 4 St. 234, the validity of which is not disputed. Wisconsin vs. Duluth, 96 U. S. 379. Of course these acts do not grant the right to discharge sewage, but the case stands no differently in point of law from a suit because of the discharge from Peoria into the Illinois, or from any other or all the other cities on the banks of that stream.

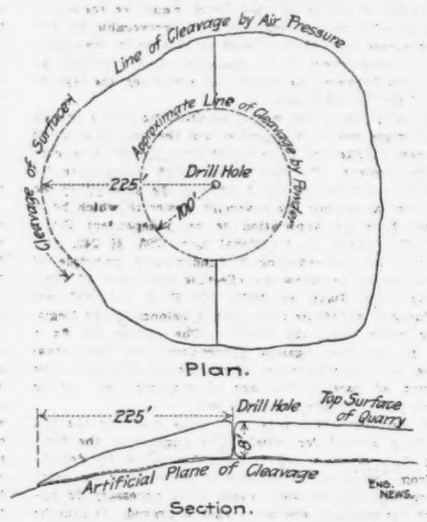
We might go more into detail, but we believe that we have said enough to explain our point of view and our opinion of the evidence as it stands. What the future may develop of course we cannot tell. But our conclusion upon the present evidence is that the case proved falls so far below the allegations of the bill that it is not brought witnin the principles heretofore established in the cause.

Bill dismissed without prejudice.

SPLITTING ROCK IN A QUARRY BY AIR PRESSURE.

A novel application of compressed air in quarry work is its use for splitting or cleaving the solid rock to create working faces or ledges. The property of the North Carolina Granite Co., of Mt. Airy, N. C., covers a gently sloping hillside, and consists of a solid homogeneous mass of moderately hard granite, which shows no ledges or bed planes, but splits readily on a straight line in almost any direction. This property is taken advantage of to create artificial ledges, large sheets or laminations of stone being separated from the mass and then broken up into the required sizes for various purposes.

In commencing operations on a selected area, as in the accompanying cut, a drill hole 2 or 3 ins. diameter is sunk to a depth of 6 or 8 ft., according to the thickness of the stone required. The bottom of this is chambered out by exploding half a stick of dynamite, after which a charge of about a handful of black powder is exploded in the pocket, starting a horizontal crack or cleavage across its greater diameter. Successive charges of increasing quantity are exploded until the cleavage has extended to a radius of 75 to 100 ft. in all directions. A pipe with a globe valve is then cemented into the drill hole and connected to the pipe line from an air compressor. The pressure carried is 70 to 80 lbs., and the air is gradually admitted, extending the cleavage until it comes to the surface on the slope of the hill, as shown in the accompanying cut. A sheet of several acres in extent may be separated in this manner, having an approximately horizontal bed plane, and stone of any desired thickness can be obtained from this, the ledge being worked with quarry bars and drills in the usual way.



Splitting Stone in a Quarry by Air Pressure.

The pressure must be turned on gradually, or the line of cleavage will turn up to the surface. When the work is under pressure the stone can be heard cracking in all directions. The time required to extend the cleavage for 100 ft. by the use of powder, as shown in the cut, was between two and three weeks, but splitting it by air for an approximate radius of 225 ft. required only half an hour.

The original practice was to use powder entirely, but this required a considerable amount of powder and considerable time, as the force of the explosions would bring the cleavage abruptly to the surface unless great care was taken and time allowed for the stone to split gradually under the influence of its natural contraction and expansion. Experiments were tried with water under pressure after the cleavage had been started with powder, but the use of compressed air is much more economical and convenient.

A Sullivan Corliss two-stage air-compressor supplies the air for this work and for 35 plug drills, 3 tripod drills, 4 quarry bars, 15 surfacing machines and 60 small hand tools. The compressor has a piston displacement of 2,000 cu. ft. of free air per minute against a terminal pressure of 80 to 100 lbs.; its steam cylinders are 16 and 28 ins. diameter; air cylinders, 26 and 18 ins.; stroke, 42 ins. It was built by the Sullivan Machinery Co., of Chicago, who have supplied the preceding information.

AN ORDER ESTABLISHING AN 80-CT. GAS RATE IN A PORTION OF NEW YORK CITY.

The price of gas in the Borough of Manhattan, New York City, has been fixed at 80 cts. per 1,000 ft. for three years from May 1, 1905, by order of the New York State Commission of Gas and Electricity. It is also ordered that the gas shall be of not less than 22 c. p., and shall not contain, per 100 cu. ft., more than 5 grains of ammonia nor 20 grains of sulphur, nor more than a trace of sulphureted hydrogen. This order applies to the Consolidated Gas Co., which is the largest of the corporations supplying gas in Manhattan, and also to the New Amsterdam, Standard and Mutual companies. Orders will soon be issued to the companies supplying gas in the Bronx, but the nature of the order is not stated. An investigation to determine the proper price to be charged in Brooklyn by the Brooklyn Union Gas Co. is in progress.

On Oct. 31, 1905, the Consolidated Gas Co. had outstanding $101,245,000 of stocks, bonds and debentures. During the year ending on that date named it sold over 13 billions cu. ft. of gas to private consumers, and 271.2 millions for street lamp use, making a total of 13.3 billions. The income from private consumers was $13,012,206, and from street lamps $559,823.

The cost of manufacturing and distributing the gas sold to consumers averaged 60.75 cts. per 1,000 cu. ft., including repairs, replacements and also an additional sum to equalize the cost for the year with the average cost for the past 20 years; but it did not include fixed charges amounting to $936,883, as compared with the gross manufacturing and distributing cost of $7,920,077. A further sum of 1.81 cts. per 1,000 cu. ft. should be added to the cost of manufacturing gas during the year named, on account of recent requirements for increased candle power in force during only a part of the year.

The valuation of the properties of the gas company, exclusive of franchises, but including materials on hand, on Oct. 31, 1905, was $31,252,669. Certain property of the company has been taken by the city recently. This property during the condemnation proceedings was valued by the company at $2,655,000. The Gas Commission therefore states that the total value of the property of the company does not exceed $30,000,000. The valuation above given was based on the books of the company. The taxable value, as returned by the company to the State Tax Commissioners on June 30, 1905, exclusive of franchise, but allowing for depreciation, was $25,408,701. The commission states that, after making allowance for the "nature and hazard of the business and the return allowed on similar investments," it considered 8% "a reasonable return upon the actual value of the property owned by the company and used in the manufacture and distribution of gas." The company "strenuously urged" that there should be included in the valuation of its plant the sum of $7,781,000, at which its franchise is assessed by the State Board of Tax Commissioners. In opposition the commission states that it is questionable whether the franchises have any considerable value, and then continues:

> The commission believes that these franchises, granted by the people without compensation, should not be capitalized against the public, thereby compelling the public to pay a profit upon the value of the favor granted by it. The seeming injustice of requiring a corporation to pay taxes upon a franchise, and at the same time refusing to allow the capitalization of that franchise, is sophistical, not real. The franchise tax is paid by the corporation, but charged against the public as an expense of operation, and in reality is therefore paid by the consumer, not by the company.

The commission states that its conclusions, as outlined above, were reached after an exhaustive and painstanking investigation extending over nearly three months. It

> believes that the natural increase in gas sales will be greatly stimulated by the reduction in price and is satisfied that the price fixed is fair to the consumer, the public and the company.

The report and order is signed by Messrs. F. E. Gunnison, John C. Davies and Lucius L. Sheldon, constituting the Commission of Gas and Electricity in the State of New York.

It is thought probable that the Legislature of the State of New York, now in session, will pass bills now before it which will also fix the price of gas at 80 cts. per 1,000 cu. ft., thus forestalling any delay in lowering the price of gas which might be occasioned by a suit to determine the constitutionality of that portion of the act creating the Gas Commission that, it is alleged, delegates to the commission the right of legislation invested in the Legislature. It will be remembered by some that a commission of the

Legislature a year ago made an extensive investigation of the cost of gas in New York City, after which a bill was introduced in the Legislature fixing the price at 75 cts. This bill passed one branch of the Legislature, but was defeated in the other. New York is the second State to establish a commission with authority, on complaint, to investigate and fix the price of gas and electricity. The first commission with such powers was created in Massachusetts some twenty years ago.

NOTES FROM THE ENGINEERING SCHOOLS.

WORCESTER POLYTECHNIC INSTITUTE.—The trustees will begin at once the erection of a large building to serve as an electrical engineering laboratory. On its completion the quarters now occupied by the electrical engineering department will be placed at the disposal of the departments of physics and chemistry.

UNIVERSITY OF PENNSYLVANIA.—The mechanical engineering building and power plant, at 34th and Spruce Sts., were damaged by fire on Feb. 6. The lighting plant was injured to such an extent that it will probably be out of service for the balance of the academic year, the current now used being supplied by the Philadelphia Electric Co. The appartus belonging to the teaching plant was damaged by water more than by fire, and has all been moved into the new engineering building, which is nearing completion. The regular instruction work is being carried on, except in laboratories, which will probably be ready for use in four weeks. Prof. H. W. Spangler is in charge of the Department of Mechanical and Electrical Engineering.

A course of instruction in public health will be offered for the first time for the academic year 1905-6. Under this course instruction will be given in sanitary engineering and legislation, the sanitation of buildings, the inspection of meat, milk and other animal products, social and vital statistics, analyses of water, air and milk, methods of disinfection and sterilization, and also in both general and personal hygiene. The course will be under the direction of Dr. A. C. Abbott, Director of the University Laboratory of Hygiene, and also Chief of the Bureau of Health of the City of Philadelphia. This laboratory was opened on Feb. 22, 1892. Among other courses given in it has been one in practical hygiene, consisting of laboratory work from Feb. 1 to April 1. This work has dealt with air, water, sewage and refuse disposal, soils, foods, clothing, disinfection, offensive and dangerous trades, and the registration and tabulation of vital statistics.

ENGINEERING MATERIAL PRICES.

TRACK FASTENINGS—
Pittsburg f. o. b. cars—Angle bars, 1.50 to 1.75 cts.; spikes, 2.10 cts.; bolts, square nuts, 2.55 to 2.60 cts.; bolts, hexagonal nuts, 2.70 to 2.75 cts.

RAILS, STEEL—
New York—at mill—New standard sections $28; standard, second quality, $27; light sections, 12 to 25 lbs., $26 to $35; old iron, f. o. b. New York, $22.50 to $23; old steel, long lengths, $16.50 to $17; old steel, short pieces, $16 to $17.

Pittsburg—Standard sections, at mill, $28; standard, second quality, $27; light rails, 12 to 25 lbs., $27 to $35.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams and channels, up to 15-in., 1.84½ cts.; over 15-in., 1.84½ cts.; angles, 3 x 2 and up to 6 x 6, 1.84½ cts.; zees, 3-in. and larger, 1.84½ cts.; tees, 3-in. and larger, 1.89½ cts.; steel bars, half extras, 1.74½ cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 2.14½ to 2.24½ cts.; still bottoms, 2.04½ cts.; fire box, 2.24½ to 2.60 cts.

Pittsburg—Tank, ¼-in. thick and heavier, 1.60 cts.; black sheets, 27 gage, 2.30 cts.; black sheets, 28 gage, 2.40 cts.

IRON—
Pig Iron:
New York—tidewater—No. 1 X Foundry, Northern, $18.50 to $19; No. 2 X Foundry, Northern, $18.25 to $18.50; No. 2 Plain, Northern, $17.75 to $18; Gray Forge, Northern, $16.75 to $17.25; Basic, Northern, $18.25 to $18.50; No. 1 Foundry, Virginia, $18.60 to $19.10; No. 2 Foundry, Virginia, $18.10 to $18.60; Basic, Virginia, $19.10 to $19.60; No. 1 Foundry, Southern, $18.25 to $18.75; No. 2 Foundry, Southern, $17.75 to $18.25; No. 3 Foundry, Southern, $17.25 to $17.50; No. 4 Foundry, Southern, $16.75 to $17.25; No. 1 Soft, Southern, $18.25 to $18.75; No. 2 Soft, Southern, $17.75 to $18.25; Gray Forge, Southern, $16.50 to $16.75; Mottled, Southern, $15 to $16.25; Basic, Southern, $18.75.

Chicago—Lake Superior—Charcoal, $20 to $20.50; Northern Coke Foundry, No. 1, $19.50 to $19.75; Northern Coke Foundry, No. 2, $19 to $19.25; Northern Coke Foundry, No. 3, $18.50 to $18.75; Northern Scotch, No. 1, $20 to $20.25; Ohio Strong Softeners, No. 1, $20.05 to $20.30; Ohio Strong Softeners, No. 2, $19.55 to $19.80; Southern Coke, No. 1, $18.15; Southern Coke, No. 2, $17.65; Southern Coke, No. 3, $17.15; Southern Coke, No. 4, $16.65; Southern Coke, No. 1 Soft, $18.15; Southern Coke, No. 2 Soft, $17.65; Southern Gray Forge and Mottled, $16.15; Malleable Bessemer, $19 to $19.25; Standard Bessemer, $19.55; Jackson Co. and Kentucky, Silvery, 6%, $21.30; Jackson Co. and Kentucky Silvery, 8%, $23.30; Jackson Co. and Kentucky Silvery, 10%, $25.30.

Pittsburg—f. o. b. cars—No. 2 Foundry, $18.35 to $18.85; Gray Forge, $17.35; Bessemer Iron, $18.60; Ferro-Manganese, $125 to $160; Muck Bars, $32; Iron Bars, $1.95 to $2.

Cast-Iron Pipe:
New York—Carload lots, net tons, 6-in., at tidewater, $29.75.
Chicago—4-in. water pipe, $31; 6-in. and larger, $30, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—
Asphaltum:
Ventura and other California asphalts, $19 to $21 per ton at New York; Trinidad refined, $20 to $25 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.

Cement:
Rosendale or Natural, in wood, 85 cts. per bbl.; Portland domestic, in sacks, $1.15 to $1.20; in wood, $1.50 to $1.60; German Portland, $1.90 to $2.10.

Copper:
Lake, 17.75 to 18 cts.; electrolytic, 17.62½ to 17.87½ cts.; casting, 17.50 to 17.62½ cts.

Lead:
New York, spot, 5.35 to 5.45 cts.

Spelter:
New York, spot, 6 to 6.10 cts.

Tin:
New York, spot, 36.37½ to 36.50 cts.

Tar:
New York, $5 to $5.50 per bbl.

Pitch:
New York, $3 per bbl.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 65 ft., $8.50; 65 to 70 ft., $9.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.
Railroad ties—Yellow pine, 6 x 9 ins. x 8 ft., 65 to 66 cts., 6 x 8 ins. x 8 ft., 59 to 61 cts.; 7 x 9 ins. x 8 ft., 72 to 73 cts.; 7 x 8 ins. x 8½ ft., 68 to 69 cts.; 7 x 9 ins. x 8½ ft., 73 to 74 cts.

THE REINFORCED CONCRETE BINS of the Peavy grain elevator at Duluth, Minn., were subjected to a severe fire test recently by the burning of the adjacent timber working house. This elevator consists of a working house of the ordinary type standing adjacent to a group of 30 cylindrical reinforced concrete storage bins. The working house was entirely destroyed; in respect to the concrete bins the "Northwestern Miller," of Feb. 21 says:

"The concrete building went through the fire intact, and does not show the slightest injury from the terrific heat to which it was subjected for hours. The two buildings are about 35 ft. apart, and the heat from the millions of feet of dry timber in the wood house was so great that steel rails between the two were subjected to a welding and fusing temperature, while for hundreds of feet away it was so hot that men could not live in the glare. The 8 to 12 ins. of cement between this heat and the wheat within the nearest row of bins in the concrete house, were amply sufficient to protect the grain from injury.

A FORTY-STORY TOWER is planned for the Singer Building on lower Broadway in New York City. The present office building of the Singer Manufacturing Co. is a 14-story structure on Broadway near Liberty St. According to the plans it and the adjacent 11-story Bourne Building are to be combined into a 15-story structure having a frontage on Broadway of 132 ft. 10¼ ins., and on Liberty St. of 270 ft. 7¼ ins. The tower will rise from the center of the new structure to a total height of 594 ft., or 392 ft. above the main building roof, which will be 202 ft. high. This tower will be 65 ft. square, and the upper four stories will be in the form of a dome, crowned with a cupola and flagstaff. The tower skeleton is to be of steel, and its facades are to be of ornamental brick and limestone. From the eleventh to the 36th story there is to be a great central bay, with double windows and a row of four single windows on each side at each floor. There will be four elevators in the tower in addition to two large inner courts, and the floor space of the tower alone will be more than 150,000 sq. ft. The total estimated cost of the new building, including the tower, is given as $1,500,000.

A LIMITED FRANCHISE COMMISSION, appointed under a resolution of the New Jersey Legislature passed in 1905, has submitted a report recommending that future franchise grants by municipalities should be for a short term of years only, and that the state should control the capital stock of companies of this class.

PLANS FOR A MUNICIPALLY-OWNED STREET railway on Geary St. and elsewhere in San Francisco, Cal., have been approved by the Board of Supervisors (corresponding to a city council elsewhere). The plans were made by Mr. Thos. P. Woodward, City Engineer, and provide for converting the present street railway line into an underground electric conduit system. The estimated cost is $328,000. The city clerk has been authorized to advertise for bids for the work.

MUNICIPAL OWNERSHIP OF A STREET RAILWAY system at Portland, Ore., is proposed. An "Initiative Committee" has been appointed to further the scheme. It is expected that a popular vote on $5,000,000 of bonds for 25 miles of railway, and also for docks, two bridges above ship-mast level, 25 miles of boulevards and a series of parks will be taken in June. Mr. Douglas W. Taylor is city engineer of Portland.

AN UNUSUAL BRIDGE will be built across the "Royal Gorge" of the Colorado River, near Cañon City, Colorado, according to newspaper reports of the last few days. It is proposed to cross this vertical-sided cañon at the top, nearly 3,000 ft. above the river. The Denver & Rio Grande Ry. runs in the cañon, alongside the river, and crosses the stream by its noted hanging bridge. The upper-level structure is part of an electric interurban line, which it is planned to build, from Cañon City to Florence.

A SECOND GREATER PITTSBURG BILL has been passed by the Special Session of the Pennsylvania Legislature. A year or two ago a bill was passed consolidating Pittsburg and Allegheny, but the bill was declared unconstitutional.

A REMARKABLE BRIDGE PIER ACCIDENT occurred at Green Bay, Wis., on the night of Feb. 13. A bridge across the Fox River is being built at that place by the Chicago & Northwestern Ry., as part of a new cut-off line in the northeastern part of the state, between Manitowoc and Gillett. The piers for this bridge were recently completed. They are in soft, uncertain ground, and have shown serious settlement. On the night of Feb. 13 the center pier, which had previously exhibited unsymmetrical settlement resulting in a lean to one side, suddenly tipped over and fell into the river. The water at that point is about 40 ft. deep, and the pier was 32 ft. high above the water surface. The foundation was of piles, cut off about 10 ft. below water; the masonry rested on the piles at this level. The pier will have to be rebuilt.

THE LARGEST SAILING SHIP IN THE WORLD was launched at Bremerhaven, Germany, on Feb. 8. It is a five-masted vessel, 438 ft. long, with 54-ft. beam and 8,000 tons burden, equipped with auxiliary motive power for use in a calm or in working in and out of harbors.

PERSONALS.

Mr. W. F. Tye, Chief Engineer, of the Canadian Pacific Ry., has resigned.

Mr. D. M. McKey, Chief Engineer of the Chicago, Anamosa & Northern Ry., has resigned.

Mr. H. H. Fox, Superintending Engineer, is appointed Superintending Engineer Architect at Rangoon, Burma, India.

Mr. F. B. Sheldon is appointed an inspector in the District of Columbia water department, succeeding Mr. Frederick A. Farling, resigned.

Mr. Geo. W. Vaughn has been appointed Engineer-in-Charge of the track elevation of the Atchison, Topeka & Santa Fe Ry., with headquarters at Joliet, Ill.

Mr. F. Ringer, Resident Engineer of the Missouri, Kansas & Texas Ry. System, has been appointed Principal Assistant Engineer, with office at Parsons, Kan.

Mr. A. B. Campbell has resigned as General Superintendent of the Buffalo, Bradford & Kane R. R., to accept a position with the Buffalo & Susquehanna Ry.

Mr. J. B. Chapman, A. M. Inst. I. C. E., Executive Engineer, P. W. D., Bombay, was recently appointed Executive Engineer, Dharwar Irrigation District, India.

Mr. W. R. Crumpton has been appointed General Manager of the Ohio River & Western Ry., with office at Woolsfield, O., to succeed Mr. J. K. Geddes, assigned to other duties.

Mr. M. E. Wells has been appointed Assistant Master Mechanic of the Wheeling & Lake Erie R. R. Co., and the Wabash-Pittsburg Terminal Ry. Co., with headquarters at Columbia, Ohio.

Mr. W. M. Legg, General Manager of the Georgia, Florida & Alabama Ry., and the Carrabelle, Tallahassee & Georgia R. R., at Bainbridge, Ga., has resigned and will retire on March 1.

Mr. John Leibfried, of Bethlehem, Pa., has been appointed from the classified service as cement expert, in the U. S. Reclamation Service. Mr. Leibfried is a graduate of Lehigh University.

Mr. W. H. McIntyre, of New York, has been elected President of the San Antonio & Aransas Pass Ry. Mr.

William Hoffs has been appointed Vice-President and General Manager, with headquarters at San Antonio, Tex.

Mr. Joseph W. Savage, for the past two years Water Register of the Borough of Manhattan, New York, has been appointed as Secretary to the Department of Docks and Ferries, to succeed Mr. Robert Baker, who has resigned.

The offices of Mr. George D. Wadley, Vice-President and General Manager and the offices of the auditor and general freight and passenger agent of the Atlantic & Birmingham Ry., have been removed from Waycross to Atlanta, Ga.

Mr. J. V. Votaw has been appointed Superintendent of the Chicago, Burlington & Quincy R. R., at Brookfield, Mo., to succeed Mr. S. H. Ustick, who has been transferred to Aurora, Ill., to take the place of Mr. W. D. Throop, promoted.

Major E. C. Lewis, President of the Nashville Terminal Co., and a director of the Nashville, Chattanooga & St. Louis Ry., has been elected to the position of acting president of that road, to fill the vacancy caused by the death of John W. Thomas.

Mr. W. A. Whitney, Superintendent of the Wyoming division of the Union Pacific R. R., has tendered his resignation, effective March 1. He probably will be succeeded by H. L. Anderson, formerly of Salt Lake City, Utah, and now Assistant Superintendent.

Mr. H. M. Brinckerhoff, who was formerly General Manager of the Metropolitan West Side Elevated Ry. of Chicago, has become associated with Mr. William Barclay Parsons, in charge of electrical and mechanical engineering work, with offices at 60 Wall St., New York.

Mr. A. H. Perkins, Engineer, U. S. Reclamation Service, has been transferred from the Washington office to duty at Cody, Wyo., on the Shoshone Project. Mr. Perkins is a graduate of the Civil Engineering Course, Cornell University, 1894, and was transferred to the Reclamation Service from the Bureau of Engineering in the Philippine Service.

Mr. Henry W. Parkhurst, M. Am. Soc. C. E., was seriously injured on Feb. 20, by being struck by a train on the Illinois Central R. R., at Chicago. Mr. Parkhurst was for several years Engineer of Bridges and Buildings of the Illinois Central R. R., and has recently been engaged in private practice.

Mr. Morton H. Anderson, until March 1, Superintendent of the De La Vergne Machine Co., of New York City, has resigned from that position to accept a similar position with the Reliance Works of the Allis-Chalmers Co., of Milwaukee, Wis. Mr. Anderson for 15 years was employed by the Allis-Chalmers Co., previous to his association with the De La Vergne Machine Co.

Recent changes have taken place in the personnel of the U. S. Reclamation Service, as follows: Mr. George H. Bliss, Engineer, has been assigned to duty on the Lower Yellowstone Project, under Mr. F. E. Weymouth, Glendive, Mont.; Mr. W. P. Hardesty, Assistant Engineer, now employed on Truckee-Carson Project, will be transferred for duty under Mr. H. M. Savage, at Billings, Mont.

Mr. Albert Ladd Colby has opened an office in New York City as a Consulting and Inspecting Engineer and iron and steel metallurgist. Mr. Colby is one of the best known of American metallurgical engineers. For 18 years he was in the service of the Bethlehem Steel Co., and for the past two years he has been Assistant to the President of the International Nickel Co., and has been the company's nickel-steel expert. He is the author of a treatise on steel specifications and has made many valuable contributions to technical literature. He is a member of the National Societies of Civil, Mechanical and Mining Engineers of the Iron and Steel Institute, the American Chemical Society, the Society of Chemical Industry and has been Secretary of the Association of American Steel Manufacturers. His offices in New York City are at 477 Central Park West.

Obituary.

Morris Stein, of Lima, O., Assistant Auditor of the Western Ohio Traction Co., was instantly killed in a rear end trolley collision at Lima, O., on February 19.

George D. MacMillan, President of the La Crosse Gas & Electric Co., of La Crosse, Wis., died at his home in that city on Feb. 12 of uraemic poisoning. Mr. MacMillan was 61 years of age at the time of his death.

William A. Shoemaker, formerly secretary of the Cincinnati, New Orleans & Texas Pacific R. R. died suddenly at his home in Cincinnati, O., on Feb. 21. He was 66 years old. He was a brother of Henry E. Shoemaker, the New York financier and railroad magnate.

Samuel Thomas, one of the pioneers of the pig iron trade in this country and a founder of the Thomas Iron Co., of 95 Liberty St., New York, died at his home in Catasauqua, Pa. Mr. Thomas was born in Ynescedwyn, South Wales, on March 13, 1827. From 1864 to 1887, he was president of the company, resigning then to become a director. He is survived by a widow, a son and a daughter.

Oswald Brown, M. Inst. C. E., a well-known authority on water-works design, died on Feb. 10 at Wimbledon, Surrey, England, at the age of 58. Mr. Brown was the superintendent of the erection of the pumping plant of the Berlin water-works, and later on he constructed the Galatz, Roumania, water-works system, and designed and constructed the water-works at Pernambuco, Brazil, and other large projects. He was appointed Hydraulic Engineer to the South Australian Government in 1875. In late years Mr. Brown was engaged in private practice as a consulting engineer.

John Stanton, one of the most conspicuous men in the copper industry in the United States, died at his residence, 419 West 23d St., New York, on Feb. 23, after a brief illness. Mr. Stanton was born in Bristol, England, on Feb. 25, 1830. He was a director in the Atlantic Mining Co., the Baltic Mining Co., the Central Mining Co., the Locke Drill Co., the Michigan Copper Mining Co., the Mohawk Mining Co., the Phoenix Consolidated Copper Co., the Winona Copper Co., and the Wolverine Copper Mining Co. He was one of the founders of the New York Metal Exchange in 1876, and for two years was its president. After that he became its treasurer until his death. He was also one of the founders, and for two years president of the Engineers' Club. He was a member of the American Institute of Mining Engineers of the Lake Superior Mining Institute, and of the North of England Institute of Mining and Mechanical Engineers. He also was a member of the Union League and Lotos clubs, and the Down Town Association. In 1857 Mr. Stanton married Miss Elizabeth R. McMillan of New York, who survives him. There were three children, all of whom are living, John R. Stanton, Frank M. Stanton, and a daughter. John R. Stanton has been associated with his father and Joseph E. Gay in business interests in this city.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 20 22. Annual meeting at Chicago, Ill. Secy., L. C. Fritch, 1532 Monadnock Block, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
April 25. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 1 to 4. Semi-annual meeting at Chattanooga, Tenn. Secy., F. R. Hutton, 12 West 31st St., New York City.

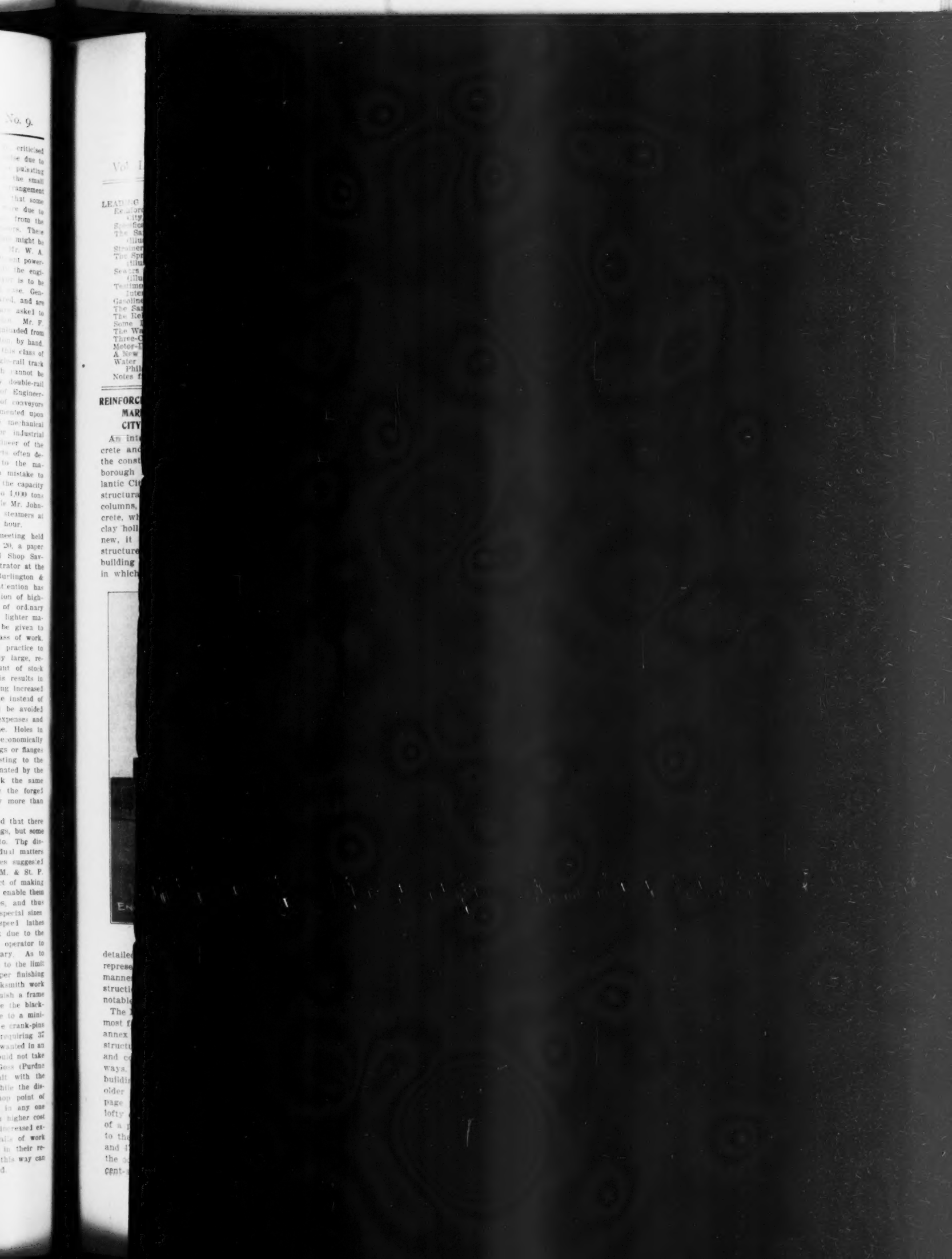
APPALACHIAN ENGINEERING ASSOCIATION.—At the close of this young society's first year, its secretary reports a membership of 45. Well-attended meetings have been held during the year, at Williamson, Huntington and Bluefield, W. Va. The association has published seven bulletins, with blueprint illustrations. Last but not least, a cash balance of $53, more than one-third the total receipts, is reported.

CENTRAL ELECTRIC RAILWAY ASSOCIATION.—This association was organized at Dayton, O., in January, as a consolidation of the Ohio Interurban Railway Association and the Indiana Electric Railway Association. At the joint meeting, a paper on "Lightning Arresters" was read by Mr. J. V. E. Titus (Garton-Daniels Co.), and several members described their practice in making grounds for the arresters. Offices were elected as follows: President, E. C. Spring, Dayton, O.; Vice-Presidents, C. L. Henry and F. D. Carpenter; Treasurer, W. F. Mulholland, Indianapolis.

VEREIN DEUTSCHER INGENIEURE.—The fiftieth anniversary of this society will be celebrated in connection with the annual meeting of the society, to be held at Berlin on June 10 to 14, 1906. While by no means the oldest, the Society of German Engineers is the largest technical society in the world. It has now over 20,000 members, and is growing quite as rapidly, in proportion to size, as any other important technical society. The importance of the society in size as well as in the fact that it counts among its members all the prominent technical men of Germany, lends special interest to the coming celebration of its semi-centennial.

WESTERN SOCIETY OF ENGINEERS.—At the meeting on Feb. 21, a paper on "Elevating and Conveying Machinery," was read by Mr. S. F. Joor, of the Jeffrey Mfg. Co. The paper dealt with continuous conveyors, and did not include cableways, telpherage, or cable haulage systems. The materials handled include those delivered in bulk (coal, grain, etc.) and those delivered in packages, and for these various forms of belt and chain elevators and conveyors are employed.

Mr. C. K. Baldwin, of the Robins Belt Conveyor Co., remarked upon the impracticability of using canvas belts in the open air owing to their changes under atmospheric conditions. He also said that the paper gave the limit of length of belt conveyors as 500 ft., whereas conveyors up to 1,000 ft. are in use, but Mr. Joor explained that he referred particularly to warehouse work. Mr. Johnson, of the Link Belt Machinery [illegible] criticised the post-office elevators on account of the [illegible]se due to the use of chains of long pitch, and also to [illegible]pulsating motion caused by the long-pitch chain [illegible] the small sprocket wheel, there being no equalizing [illegible]rangement in the driving machinery. He also thou[illegible] that some of the troubles with the post-office plant [illegible]e due to allowing the contractors to vary too wi[illegible] from the original specifications prepared by the engi[illegible]rs. These required chains of 6 ins. pitch, but while [illegible] might be too small, 24 ins. was certainly too grea[illegible]. W. A. Shaw, City Engineer, stated that for the di[illegible]ent power-houses of the city the decision is made [illegible] the engineer's office as to what type of coal conve[illegible] is to be used, best suited to the conditions in each case. General plans and specifications are then prepared, and are sent to the different manufacturers, who [illegible] asked to submit details conforming to the general plan. Mr. F. S. Hickok said he had known of coal being unloaded from cars by contract at costs of 3 to 10 cts. per ton, by hand. A grab bucket is an economical device for this class of work, and if handled by a trolley on a single-rail track it can be run around sharp curves, which cannot be done if the trolley travels on an ordinary double-rail runway. Mr. Tratman, Associate Editor of Engineering News, referred to some special forms of conveyors not mentioned in the paper, and also commented upon the necessity of due consideration of the mechanical equipment in the design of buildings for industrial plants, etc. Mr. W. L. Abbott, Chief Engineer of the Chicago Edison Co., remarked that architects often design power stations without due regard to the machinery equipment; he also considered it a mistake to use a coal conveyor to carry ashes. As to the capacity of conveyors, Mr. Baldwin mentioned 750 to 1,000 tons of coal per hour being handled by belts, while Mr. Johnson stated that chain conveyors for coaling steamers at Seattle have handled 1,100 tons of coal per hour.

WESTERN RAILWAY CLUB.—At the meeting held at the Auditorium Hotel, Chicago, on Feb. 20, a paper was presented on "Some Small Successful Shop Savings," by Mr. C. J. Crowley, Shop Demonstrator at the West Burlington shops of the Chicago, Burlington & Quincy Ry. His point was that while attention has properly been paid to the design and operation of high-power machine tools, a large proportion of ordinary railway machine shop work can be done on lighter machines, and that greater attention should be given to these machines and the economy of this class of work. Among other matters it is a very general practice to make such castings as pistons unnecessarily large, requiring the removal of an excessive amount of stock when finishing the piston in the lathe; this results in loss of material in time, the latter loss being increased if the work is done in an ordinary machine instead of a modern high-speed machine. This could be avoided by a very small increase in pattern shop expenses and finishing with a grinder instead of a lathe. Holes in castings may be cored and reamed more economically than they can be drilled in the solid, and lugs or flanges whose sole purpose is for attaching a casting to the force plate for finishing may often be eliminated by the design of a proper chuck. In forge work the same principle applies, and on an engine frame the forge1 size should not exceed the finished size by more than ¼-in.

In the discussion it was generally admitted that there is a field for effecting important small savings, but some of Mr. Crowley's examples were objected to. The discussion, however, dealt mainly with individual matters of detail, and did not follow along the lines suggested by the paper. Mr. A. E. Manchester (C. M. & St. P. Ry.) pointed out that in many cases the fact of making pistons or other castings of liberal size may enable them to be used for engines of different classes, and thus avoid carrying a large stock of castings of special sizes. In turning driving-wheel tires in high-speed lathes there is a possibility of uneconomical work due to the ease of taking a heavy cut, inducing the operator to remove more metal than is really necessary. As to forging frames, if they are forged too close to the limit the lathe may not be able to take a proper finishing cut. Mr. De Voy also remarked that blacksmith work is costly, and that it is much cheaper to finish a frame in a modern slotter or planer than to have the blacksmith spend extra time in reducing the size to a minimum. Mr. Barnum referred to a case where crank-pins were forged almost to the finished size, requiring 37 sizes to be kept in stock, but when one was wanted in an emergency it was so small that the lathe could not take a proper finishing cut. Prof. W. F. M. Goss (Purdue University) remarked that the paper dealt with the matter from the foundry point of view, while the discussion was mainly from the machine shop point of view. While small savings may be made in any one shop, it is possible that these will result in higher cost in another shop, with an ultimate result of increased expenditure rather than a saving. The details of work must not be considered independently, but in their relation to the work as a whole, and only in this way can definite and final savings in cost be obtained.